College of Science
2019-2025 Strategic Plan

2019-2025

2019 – 2025 College of Science Strategic Plan

Vision

The College of Science will be recognized as a national model for its significant contribution and impact in making our communities and our world better, fair, diverse and inclusive. This will be accomplished by preparing world leaders who will expand the frontiers of science and mathematics and their application in identifying solutions to societal and global challenges, systemic inequities, and will contribute to a society that embraces justice for all people.

Mission

The College of Science prepares graduates for careers in the physical, life, and mathematical sciences and provides mathematical and scientific foundations for all RIT students through academic programs and impactful innovative research that expand scientific knowledge and develop new technologies to advance the sciences and their application to society and our environment. We embrace social justice and equity related to but not limited to education, research, and the scientific community at large.

Guiding Principles

- Student Success
- Academic Excellence
- Faculty and Staff Success
- Diversity, Social Justice, and Inclusive Excellence
- Synergy and Outreach
- Environment and Infrastructure
- Academic Operations

Overarching Goals

The College of Science will pursue its vision to be known for the high-quality education it provides for its students, its world-class research and expertise in target areas, its innovative, person-centered approaches to teaching and learning, and its graduates who will be equipped with cutting edge knowledge and will be prepared, through experiential learning and deep understanding of the principles of equity, social justice, and inclusive excellence, to succeed in their chosen careers.

I. Robust and Signature Academic Programs

<u>GOAL - 1</u>: Provide excellent mathematics and science foundation courses for all RIT students and develop and support academic programs that will instill interdisciplinary inquiry and intellectual growth, and will prepare our graduates for careers in a rapidly changing global marketplace

Objectives	Action Items and	Academic Year to be	Project Leader or Group

	STRATEGIES	IMPLEMENTED OR TO START THE IMPLEMENTATION	
Objective 1: Maintain and develop rigorous academic programs that offer a balance between fundamental skills, advanced theoretical work, and experiential learning opportunities that expose students to open-ended problems and real-life applications and prepare them for graduate studies and successful careers in the global marketplace.	**Action Item 1:** Continue to explore ways to enrich current curricula by broadening inclusion of undergraduate research, study abroad, entrepreneurship, and co-op experiences. **Action Item 2:** Introduce a flexible first year curriculum for all undergraduate students in the College of Science. **Action Item 3:** Assess potential changes to current programs in response to: ▪ needs in the current workforce environment; ▪ current trends in graduate program admissions; ▪ recent alumni placements; ▪ student needs; ▪ needs for current and up to date curriculum that includes new developments in the field; and ▪ needs in support of the research initiatives of the COS. *** Please see **Appendix A** for more details	**2018-19** **2018-19** **Annually**	**Heads and Academic Unit Curriculum Committees** **Associate Dean for Academic Affairs, and COS Curriculum Committees** **Heads, Associate Dean for Academic Affairs, and Academic Unit Curriculum Committees**
Objective 2: Develop Interdisciplinary	**Action Item 1:** Assess potential discipline areas by collecting data from current	**2018-19**	**COS Curriculum Committee**

Science programs that: - will cut across disciplines and will immerse students on the front lines of interdisciplinary, team-based, world-class level research that has practical relevance in the world of careers beyond academia; - will provide focus with concentration in a single science field, and - will provide graduates with a well-rounded appreciation of science and its place in society.	faculty, employment sources, and federal employment databases. **Action Item 2:** Explore ***specific and targeted*** inter-/multi-disciplinary areas of studies by focusing on possible collaborations between COS programs and other colleges at RIT and consider offering more dual BS/MS programs that span more than one discipline.	 **2018-19**	 **COS Curriculum Committee**
Objective 3: Enhance and expand the science and mathematics student population and the profile of the College of Science student body.	**Action Item 1:** Actively recruit outstanding students. **Action Item 2:** Develop and maintain strategies to help students make appropriate progress through their academic programs.	**2018-19** **2018-19**	**Heads, Associate Heads, and Leader Faculty for Academic Success, Recruitment and Retention.** **Heads, Associate Heads, and Leader Faculty for Academic Success, Recruitment and Retention.**

Objective 4: Promote global literacy and cultural awareness.	**Action Item:** Increase faculty and student participation in the study abroad and international education programs.	**Annually**	**Heads, Associate Dean for Academic affairs, and Leader Faculty for Global and International Education.**
Objective 5: Promote and grow online learning.	**Action Item:** Increase the number courses and programs that can be offered online. Consider offering online the following programs: ▪ BS in Applied Statistics and Actuarial Sciences ▪ MS in Color Science ▪ BS and MS in Bioinformatics ▪ MS in Applied and Computational Math	**Annually**	**Heads, Associate Dean for Academic affairs, and Leader Faculty for Online Learning.**
Objective 6: Outreach and attract female and minority student in science and mathematics disciplines and increase overall diversity in all levels of science and mathematics education.	**Action Item:** Develop and support projects that encourage the participation of minority students in science and mathematics.	**Annually**	**Heads and Academic Unit Curriculum Committees**

II. Growth of Research Programs

GOAL - 2:
Build on our successes and develop and support active, world-class, cross-disciplinary research programs and centers of excellence that will attract first-rate

scientists to RIT, will provide rich, person-centered diverse and inclusive learning environments for our students, and will be supported by grants, foundations, and industrial sponsorship.

Objectives	Action Items and Strategies	Academic Year to be Implemented or to Start the Implementation	Project Leader or Group
Objective 1: Establish a national and international College of Science presence for RIT through investment in strategic areas where we can be successful.	**Action Item 1:** Establish a distinguished visiting scholar program to promote faculty exchange visits and allow for distinguished scholars in selected areas to visit for an extended period (~1 month), to deliver guest lectures, interact with grad/undergrad students, faculty and research groups.	**2019-20**	**Associate Dean for Research and Faculty Affairs, Heads of Academic Units**
	Action Item 2: We will invest in: ▪ Established Strong Areas ▪ Emerging Areas ▪ Strategic Areas ▪ Various Opportunities and Initiatives *** Please see **Appendix B** for more details	**Annually**	**Associate Dean for Research and Faculty Affairs, Heads of Academic Units**
Objective 2: Encourage and support the scholarship of discovery, pedagogy, integration, and application by faculty and students.	**Action Item 1:** Establish an environment that can identify and encourage faculty to establish successful research groups and support continued growth. Connect promising new faculty with successful research groups.	**Annually**	**Associate Dean for Research and Faculty Affairs, Heads of Academic Units**

	Action Item 2: Identify faculty with early success and high potential and properly mentor and incentivize them to grow research further.	**Annually**	**Associate Dean for Research and Faculty Affairs, Heads of Academic Units**
	Action Item 3: Create and encourage regular journal club-like and/or un-themed coffee-hour meetings for faculty and research staff.	**Annually**	**Associate Dean for Research and Faculty Affairs, Heads of Academic Units**

III. Faculty and Staff Professional Growth

GOAL - 3:
Promote, support, and enhance a vigorous, diverse, inclusive, and rewarding academic environment that fosters faculty and staff professional growth, job satisfaction, impartiality, social justice, equality and equity for all members of the College.

Objectives	Action Items and Strategies	Academic Year to be Implemented or to Start the Implementation	Project Leader or Group
Objective 1: Continue to provide an environment of support, mentorship, and collegiality to encourage faculty and staff professional growth.	**Action Item 1:** Put in place a training program to assist new faculty, lecturers and teaching assistants in effective teaching practices.	**Annually**	**Associate Dean for Research and Faculty Affairs, Heads of Academic Units**
	Action Item 2: COS support staff will have opportunities to enhance their professional mobility.	**Annually**	**Associate Dean for Academic Affairs, Heads of Academic Units**

IV. Partnerships (External and Internal) and Outreach

GOAL - 4:
Develop partnerships and outreach programs with business, industry, government, K-12 community, alumni, and other RIT academic and business units in support of the goals of the College and Institute.

OBJECTIVES	ACTION ITEMS AND STRATEGIES	ACADEMIC YEAR TO BE IMPLEMENTED OR TO START THE IMPLEMENTATION	PROJECT LEADER OR GROUP
Objective 1: Cultivate interactions with business, industry, and government to develop and implement collaborative programs in mathematics and the sciences.	**Action Item 1:** Evaluate existing advisory boards at the school level and create new ones or reformulate existing ones as appropriate.	**2019-20**	**Dean and Heads**
	Action Item 2: Develop and implement a plan to best utilize advisory boards at the school level and at the college level.	**2019-20**	**Dean and Heads**
	Action Item 3: Create and implement a strategy for industrial support of COS research in conjunction with the all the COS advisory boards.	**Annually**	**Associate Dean for Industrial Partnerships and Heads**
	Action Item 4: Develop a COS brand, marketing techniques, and strategies (e.g. Twitter presence, documentary on COS, COS apparel, etc.).	**2019-20**	**Associate Dean for Academic Affairs, Web and Social Media Manager, and Heads of Academic Units**
Objective 2:	**Action Item 1:** Develop	**2018-19 and**	**Associate Dean**

Establish and maintain collaborations with K-12 community in response to needs for additional knowledge and skills in science and mathematics and to help prepare the next generation of STEM educators.	articulation agreements with Schools of Education –to streamline the process of teacher certification in math and science disciplines. **Action Item 2:** Establish agreements with local schools for RIT students to shadow science/math teachers. **Action Item 3:** Develop and support internship programs that will attract high school students to work with our faculty and gain hands on experience in our laboratories during the summer months. **Action Item 4:** Develop and implement COS-based activities, competitions, and events at ImagineRIT and other similar events. **Action Item 5:** Coordinate and publicize the various K-12 activities already taking place in COS and develop additional coordinated programs as needed.	**2019-20** **Annually** **Annually** **Annually** **Annually**	**for Academic Affairs and Heads** **Associate Dean for Academic Affairs, Heads, and Associate Heads** **Associate Dean for Academic Affairs, Heads, and Associate Heads** **Associate Dean for Academic Affairs, Heads, and Associate Heads** **Associate Dean for Academic Affairs, Web and Social Media Manager, and Heads of Academic Units**
Objective 3: Cultivate new and existing collaborations with international organizations and	**Action Item:** Develop and implement targeted programs for international student exchanges, faculty exchanges, course sharing, and other international	**2018-19 and 2019-20**	**Heads, Associate Dean for Academic affairs, and Leader Faculty for Global and**

educational institutions.	exchange programs.		**International Education.**

V. State of the Art Facilities and Infrastructure for Excellence in Science and Mathematics

GOAL - 5:
The College of Science will be housed in state-of-the-art facilities and will provide infrastructure that will enable excellence in science and math education and research.

OBJECTIVES	ACTION ITEMS AND STRATEGIES	ACADEMIC YEAR TO BE IMPLEMENTED OR TO START THE IMPLEMENTATION	PROJECT LEADER OR GROUP
Objective 1: Complete the renovation of the Gosnell building and consolidate college academic units in fewer buildings through the construction of a new cross-disciplinary Science and Engineering Research building that will support our research mission and will foster collaborations and cross-disciplinary interactions. *** This is part of the RIT Strategic Plan	**Action Item 1:** Develop a specific plan for a new cross-disciplinary Science and Engineering Research building to obtain the necessary funding, through the RIT "capital campaign," to begin construction.	**2018-19**	**Executive Council**
	Action Item 2: Create and implement a plan that will be used as a guide to best utilize existing laboratories, for both teaching and research, and to share research infrastructure in order to most efficiently use current and potential future space.	**2018-19**	**Executive Council and Space Committee**
	Action Item 3: Create more collaborative space for research interactions and for student and faculty to gather within existing space and within any new construction.	**2019-20**	**Executive Council and Space Committee**

Objective 2: Continue to improve infrastructure that supports our teaching and research mission and facilitates career advancement and job satisfaction for all members of the College.	**Action Item 1:** Devise a plan to be used for allocating research space efficiently based on external funding and significant outcomes (i.e. publications, patents, and other deliverables). **Action Item 2:** Campaign for funds to provide new faculty with appropriate and sufficient startup packages (e.g., equipment, graduate student stipends, salary for post-docs or technicians).	**Annually** **Annually**	**Executive Council and Space Committee** **Executive Council**

APPENDIX A: COS 7-YEAR ACADEMIC PROGRAMS MASTER PLAN

Ph.D. Programs

- Physics
- Materials Science and Engineering (with KGCOE)
- Applied Statistics
- Earth Systems Science
- Machine Learning
- Chemistry

M.S. Programs

- Biotechnology

BS/BA Programs

- Biotechnology/Biotechnology
- Biochemistry/Biotechnology
- Data Analytics/Data Science
- Mechanical Engineering/Materials Science
- Computational Math/Materials Science
- Applied Statistics & Actuarial Science/Data Science
- Applied Math/Data Science
- Applied Statistics & Actuarial Science/Computational Finance
- Computational Math/Computational Finance
- Applied Math/Computational Finance
- Physics/Physics

BS Programs

1. Integrated Science
2. Data Analytics
3. Machine Learning

BA Programs

4. Applied Cognitive Neuroscience
5. Options for existing B.S. programs

Ph.D. Programs

Ph.D. - Physics

Description

As RIT aspires to become recognized as one of the nation's preeminent research universities, it is critical that we move aggressively towards building a portfolio of strong PhD programs in the traditional core STEM disciplines. Establishing a PhD program in Physics is particularly essential as the discipline provides the underpinnings for all subfields of fundamental science, applied science, engineering, and technology. Research areas in the field of physics, in several of which SoPA already has a significant presence, naturally align with many of the strategic priorities of federal and other funding agencies, as exemplified by NSF's current "10 Big Ideas." An overarching Physics PhD program would raise the national and international profile of the RIT School of Physics and Astronomy (SoPA), as well as the University as a whole. Even beyond the graduate level, the presence of a PhD program would also positively impact our ability to attract the best undergraduates, provide them with yet more research opportunities, and create an environment that would organically seed graduate-undergraduate-postdoctoral research teams and collaborative connections. The presence of the program and its faculty would naturally strengthen, complement, and serve as an important resource for a number of existing RIT PhD programs such as those in Astrophysical Sciences & Technology, Imaging Science, Mathematical Modelling, and Microsystems Engineering, as well as for terminal M.S. programs like those in Chemistry and Materials Science & Engineering. The same is true for the obvious positive impact it would have on current RIT research centers such as the CfD, CCRG, NPRL, LAMA, and CASTLE, as well as STEM-based signature interdisciplinary research areas (SiRAs) like the *Future Photon Initiative* and *Frontiers in Gravitational-Wave Astrophysics*. Establishing a PhD Physics program is also important for developing synergies with other PhD-granting institutions (including the University of Rochester) and for accessing national laboratory resources and training/research opportunities for students.

Access to physics PhD students is a requirement for attracting, competitively recruiting, and successfully hiring top-notch faculty prospects who are pioneers in their field of research and, at the same time, are committed to strengthening RIT's tradition of providing excellent education and training at both the graduate and undergraduate levels. Even without current PhD students, we currently have many physics faculty who are well-funded (totaling approximately $2M in new awards annually), making SoPA well-positioned for supporting PhD students. However, other than in the area of astrophysics (i.e., those in the AST Program), these faculty find themselves hampered by the current absence of a viable pool of physics PhD students from which to draw in support of their research efforts. On occasion, faculty end up drawing from PhD students in other programs, but the success here has been disappointing largely due to the general mismatch between student backgrounds and/or interests and the nature of PhD-level physics projects. In order to meet their research goals, it is currently commonplace for well-funded physics faculty to hire postdoctoral researchers more often (and at a higher cost) than typically desired because there is no pool of qualified PhD students available. Without a Physics PhD program, faculty are severely handicapped when it comes to moving SoPA research to the next level, as well as securing the next level of sponsored funding.

It is worth noting that because of the new Physics M.S. Program (pending final NYSED approval for admitting students in Fall 2019), the graduate core courses/curriculum and numerous other graduate physics courses are already in place. Also, for the M.S. program we already developed a model for a robust *Individual Advising Plan* for physics graduate students, and this will easily carry over to the PhD program; this plan facilitates curricular flexibility, allowing students to specialize in chosen areas beyond the fundamental core of the program.

Recent national data from the American Institute of Physics shows that placement for Physics PhD graduates is excellent, with the initial placement rate for potentially permanent or for postdoctoral positions being 95%. In addition to traditional university faculty positions, many enter high-level jobs in industry, engineering, computer and information technology, and as research scientists at national laboratories.

Incremental Hires and Space Requirements
We estimate the incremental space needs to be about 4000 sq. ft. including 2000 sq. ft. of physics laboratory space; 700 sq. ft. of desk space for grad students; 360 sq. ft. of faculty office space; and 900 sq. ft. of general common space for congregating space for student and faculty interactions, for meeting/interacting with speakers, etc. (The latter space could also potentially be shared with the other COS PhD programs). We estimate needing about 3-4 incremental tenure-track faculty and .5 administrative/support staff person.

Ph.D. - Materials Science and Engineering

Description
Materials science and engineering (M.S.&E) combines physics, chemistry, and engineering in order to solve real-world problems in nanotechnology, biotechnology, energy, manufacturing, and other major engineering domains. By focusing on M.S.&E, RIT can invest in multiple fronts by supporting the design, development, and characterization of novel materials that can be deployed in a wide variety of industrially relevant technologies.

Federal funding for M.S.&E research is strong and will remain strong in the future. The subset of materials-related programs within NSF, DOE, and DOD have annual budgets of roughly $1.2B, $1.4B, and $0.5B, respectively. Over the past ten years, current RIT faculty with materials related work have garnered significant external research awards. About a dozen of these faculty have brought in more than $1M individually. According to the National Research Council's Survey of Doctoral Programs, 89% of faculty in M.S.&E PhD programs have external funding, higher than Chemistry, Physics, Applied Mathematics, and Civil, Computer, Electrical, and Mechanical Engineering.

A PhD program in M.S.&E will draw upon student and faculty talent from myriad disciplines, allowing them to apply their unique talents in ways that are meaningful to cutting edge research and future employers. For instance, the program could be fed by existing B.S. degrees in Physics, Chemistry, Microelectronic Engineering, Electrical Engineering, Chemical Engineering, Biomedical Engineering, and Mechanical Engineering, and existing M.S. degrees in M.S.&E, Mechanical Engineering, Electrical Engineering and Microelectronic Engineering, Engineering. The potential for this to succeed is already demonstrated: existing materials-related faculty are actively engaged in joint research, and in mentoring students at all levels, as evidenced by innumerable undergraduate capstone projects and co-ops, NSF-REU programs, and M.S. and PhD students.

M.S .&E research at RIT encompasses a large fraction of well-funded faculty research across multiple colleges and has strong potential for industrial partnerships. We presently have strengths in electronic and photonic materials; energy storage systems; correlated materials; organic electronic materials; polymers; and catalysis. Given our relatively young research emphasis, a reasonable way to grow is to form focused research groups surrounding our most productive researchers. That will allow synergies to enhance and diversify our scholarship, while streamlining instrumentation and infrastructure needs. This also has significant advantages for future focused funding opportunities: an example is the NSF's Materials Research Science and Engineering Centers. These require faculty research to be orchestrated around a common area. By growing RIT's research enterprise as proposed herein, we will be able to put together proposals that can be competitive for these large federal grants; now that is not possible.

Expanding M.S.&E research at RIT can be envisioned from a few keywords associated with high impact journal *Advanced Functional Materials*: sensors, porous materials, light emitting materials, ceramics, biological materials, magnetic materials, colloids, photovoltaics; batteries and supercapacitors; fuel cells; thermoelectrics; catalysis; solar fuels and thermosolar power; magnetocalorics; piezoelectronics.

Incremental Hires and Space Requirements

We anticipate the need for 6 incremental tenure-track faculty (capable of sustaining funded research) and .5 administrative/support staff person. We anticipate total incremental space needs of 6750 sq. ft. to include 1000 sq. ft. for each of 6 faculty research labs, 600 sq. ft. for each of 6 faculty offices, and 150 sq. ft. for desk space for 3 Ph.D. graduate students.

Ph.D. – Applied Statistics

Description

We propose a distinctive, robust and interdisciplinary Ph.D. program in Applied Statistics in which students will work at the intersection of science and engineering to study data mining, design of experiments, and statistical applications related to health care, imaging science and industry. We will prepare students for jobs in academia, government, and private industry.

The program will address growing national and state demands for individuals with doctoral training in the areas of biostatistics, business, engineering, and general applied statistics. Statistical methods are ubiquitous and used in the social, physical, and biomedical sciences and in business to process information to assist decision making. The job market has an increasing demand for individuals with the expertise in designing experiments and analyzing large complex data sets via the latest advances in computing. In particular, there is a real need for professionals with a Ph.D. degree in Applied Statistics in the fields of biostatistics and bioinformatics, business analytics and economics, engineering and industry, large data set processing and mining, and social and behavioral sciences.

In addition, the program will support and complement the current B.S. in Applied Statistics and Actuarial Science (with a current enrollment of approximately 35 students) and the M.S. in Applied Statistics (with a current enrollment of approximately 87 students).

Incremental Hires and Space Requirements
A formal proposal for a Ph.D. program in Applied Statistics is planned to be submitted in 2019 in anticipation of the first Ph.D. students beginning in the fall of 2021. We anticipate the proposal will request to grow the number of statistics faculty by three to complement the research portfolio of the current faculty and .5 administrative/support staff person. We also anticipate the need for office space for these new faculty and space for the Ph.D. students. We anticipate the need for 3 incremental tenure-track faculty (capable of sustaining funded research and teaching advanced courses). We anticipate total incremental space needs of 2000 sq. ft. to include 500 sq. ft. for each of 3 faculty research labs, 100 sq. ft. for each of 3 faculty offices and 25 sq. ft. for desk space for graduate students).

Ph.D. - Earth Systems Science

Description
We propose creation of a new transdisciplinary natural science PhD program in Earth Systems Science that will be housed in the Integrated Sciences Academy of the COS. This Graduate Group in Earth Systems Science will draw from existing faculty expertise in all Schools of the COS, providing students with strong disciplinary knowledge in a concentration, and the breadth of knowledge across disciplinary boundaries to be able to solve the complex environmental problems facing the world today.

This new program clearly aligns with the Academic Portfolio Blueprint for the University. The PhD will facilitate growth in student and faculty scholarship in ESS (Characteristic #1) and create access to PhD students for additional faculty. This is a key recruiting tool for new hires across the College and will also bolster research programs of existing faculty. The program will engender a broad understanding of global issues (Characteristic #4) foster integration within, between and among disciplines, programs and colleges, and address emerging disciplines in new areas of inquiry (Characteristic #5).

The employment opportunities for Environmental Scientists and Specialists are expected to grow 11% in the next decade, faster than average for all occupations. Similar rates of growth are posted for Geoscientists (14%), Hydrologists (11%), Atmospheric Scientists (12%), and Conservation Scientists (6%; equivalent to the average rate of growth). "Heightened public interest in the hazards facing the environment, as well as increasing demands placed on the environment by population growth, are expected to spur demand."[1]

The proposed program differs from existing PhD programs in COS in that the focus is the topic (i.e. natural-human systems) rather than the tool (Imaging, or Math Modeling). However, access to faculty in these complementary programs will give ESS PhD students a unique educational experience that sets them apart from graduates of other programs (local competitors include SUNY Environmental Science and Forestry, University at Buffalo, Cornell University).

1. https://www.bls.gov/ooh/life-physical-and-social-science/environmental-scientists-and-specialists.htm

Incremental Hires and Space Requirements
We anticipate the need for 4 incremental tenure-track faculty (capable of sustaining funded research) and .5 administrative/support staff person. We anticipate total incremental space needs of 2000 sq. ft. to include 500 sq. ft. for each of 4 faculty research labs, 100 sq. ft. for each of 4 faculty offices and 25 sq. ft. for desk space for graduate students).

Ph.D. - Machine Learning

Description
Artificial intelligence, and especially machine learning, is now rivaling or exceeding humans at solving real-world problems such as diagnosing disease, recognizing objects, face identification, and much more. Nations and companies are investing billions of dollars in this space, and the number of US jobs requiring machine learning skills have grown 4.5 times over the past four years. The global market for AI continues to increase, with the supply of capable employees being far lower than demand. Fundamental research in applied machine learning, especially deep learning, is highly active in the sciences, including astronomy, biochemistry, chemistry, ecology, imaging, and physics.

The core curriculum of a machine learning degree fits well within COS. It would be designed to train undergraduates with either a background in computational physics, math, statistics, or computer science. The curriculum would include a course on multivariate vector calculus, numerical analysis and efficiently translating linear algebra to code (e.g., NumPy), optimization, statistical learning theory, probability, computer vision, natural language understanding, general machine learning, and deep learning. A graduate-level class in algorithms and theoretical computer science may also be included. A course on conducting machine learning research, writing, and publishing papers competitive for top venues would also be developed. A course on "AI Ethics and Society" would also likely be developed, perhaps in collaboration with COLA faculty.

Incremental Hires and Space Requirements
Five tenure-track faculty over seven years (one per two advanced undergraduate electives and graduate courses) and .5 administrative/support staff person. Areas of interest include optimization, learning theory, control, human-AI interaction, natural language understanding, and applied machine learning to problems in the sciences. We anticipate needing offices (500 sqft @ 100 sqft/office) and labs (5000 sqft @ 1000 sqft/lab) for incremental faculty hires and 20 PhD students (1000 sqft @ 25 sqft/student).

Ph.D. – Chemistry

Description
We propose a PhD in Chemistry to prepare students for employment at the highest level. PhD granting institutions can attract the strongest teacher-scholars. Combined with SCMS'

established upswing of external funding and publication in leading journals (external funding has grown from $200K/year to $800K/year since 2012), we will continue this trajectory through 2021 by (1) hiring three high potential research faculty with significant startup packages, one arriving with existing funding and (2) mentoring/providing course release for four existing faculty members, currently receiving moderate funding ($30K/year), who will be positioned to increase their research productivity.

The recent dramatic upgrade in laboratory infrastructure strongly supports our undergraduates and faculty. Of RIT's 20 benchmark schools, RIT sits 8th in number of awarded Chemistry Bachelor's degrees (2015-16). Clearly, strong undergraduate research sets RIT apart from other schools. However, with this growing infrastructure, our opportunity is to grow beyond our current last-place rank (zero PhDs); a PhD program is critically needed by those faculty members who must remain competitive and support their expanding sponsored research efforts with long-term graduate students. Furthermore, when SCMS actively recruits more aspiring students for the PhD program, the strength and recognition of our M.S. program will also improve.

Incremental Hires and Space Requirements
Two proposed hires will replace teaching faculty members, requiring 1000 sq. ft. additional research space. Two permanent lecturer lines are therefore necessary to cover teaching needs resulting from this transition and .5 administrative/support staff person. We will submit a formal proposal for a Ph.D. program in fall of 2019, with plans to accept our first Ph.D. students in fall, 2021.

M.S. PROGRAMS

M.S. – Biotechnology (Thesis and Professional)

Description
The Thomas H. Gosnell School of Life Sciences (GSoLS) propose an M.S. program in Biotechnology that will expand and enhance one of RIT's signature undergraduate programs with the overarching goal to prepare graduates to meet the growing demand of the biotechnology workforce. This proposed M.S. in Biotechnology will capitalize on the forecasted trend in growth of the Biotechnology industry due to increase in recent years driven by biotechnology applications in various sectors such as; health, medical, energy, food, agriculture, and environmental sciences. An M.S. Degree in Biotechnology will train students under the guidance and mentorship of faculty to develop a plan of study and research focus that matches the student's interests and career goals. Core courses will cover advanced topics in current and relevant topics including cancer biology, and phage and viral biology, genome editing and engineering, genomes sequencing and annotation, structural biology, among others. The culmination of this training will include a research-based thesis that applies biotechnology and genetics using hypothesis-driven experimental methods to address a specific biological problem. Professional development in life sciences will also include the development of skills in: presentation approaches, scientific grant and paper writing, experimental design and ethics. In addition, the program will enable GSoLS and allied faculty to establish relationships with the industrial partners to foster collaborations.

Over the last decade the school has hired faculty whose research are aligned with biotechnology in areas such as; phage biology, genome organization, antibiotic development and plant biotechnology. The addition of a M.S. degree in this niche area to our current portfolio will allow us to be more competitive regarding our research and scholarship outcomes. Additional talent will be sought in cutting-edge biotechnology areas such as, gene editing, next generation DNA sequencing and annotation, genetic engineering and systems biology to enhance our capacity with regard to student research activities, training and productivity.

Incremental Hires and Space Requirements
We anticipate the need for 4 incremental tenure-track faculty (capable of sustaining funded research). We anticipate total incremental space needs of 2000 sq. ft. to include 500 sq. ft. for each of 4 faculty research labs, 100 sq. ft. for each of 4 faculty offices and 25 sq. ft. for desk space for graduate students).

B.S./M.S. PROGRAMS

B.S./M.S. – Biotechnology and Biochemistry/Biotechnology

Description
The above described M.S. program in biotechnology could be incorporated into our existing B.S program to include a B.S./M.S. 5-year program. In addition, we are also proposing a 4 +1 B.S./M.S. in Biochemistry/Biotechnology in collaboration with the School of Chemistry and Materials Science.

B.S./M.S. –Biochemistry/Chemistry

Description: The existing Biochemistry B.S. program will be integrated with our existing M.S. Chemistry program to create a 4+1 B.S. Biochemistry/M.S. Chemistry 5-year program.

B.S./M.S. - Mechanical Engineering/Materials Science

Description
With the advent of new classes of materials and instruments, the traditional practice of empiricism in the search for and selection of materials is rapidly becoming obsolete. Therefore, the Materials Science and Engineering (M.S.&E) M.S. degree program offers a serious interdisciplinary learning experience in materials studies, crossing over the traditional boundaries of such classical disciplines as chemistry, physics, and chemical, mechanical, and microelectronic engineering. Mechanical engineering areas relevant to M.S.&E including medical devices, energy systems, materials development, structural integrity, manufacturing, among others. Combining the B.S. in Mechanical Engineering with the M.S. in M.S.&E into a B.S./M.S. program is a natural merger. We expect successes comparable to our new B.S./M.S. between Chemical Engineering and M.S.&E.

B.S./M.S. - Computational Math/Materials Science

Description
Advanced materials are critical to economic security and human well-being, and find application

across energy, national security, and human welfare. Materials Science and Engineering researchers leverage computational methods in order to make to understand chemical kinetics and equilibria, to make predictions of the electronic and structural properties of materials, and to accelerate the discovery of new materials and properties. Given that computational methods play a central role in modern materials research studies and will only increase in importance as computing power advances in future, a B.S./M.S. program between Computational Mathematics and Materials Science and Engineering holds significant potential to address interests of students and prepare them with the cross-disciplinary skills needed to be successful in tomorrow's workforce.

B.S./M.S. – Data Analytics/Data Science
B.S./M.S. – Applied Math/Data Science
B.S./M.S. - Applied Statistics and Actuarial Science/Data Science

Description
The M.S. in Data Science program offers a unique opportunity for students in the B.S. programs of Data Analytics, Applied Mathematics, or Applied Statistics and Actuarial Science to enhance their education and better prepare them for academia or employment opportunities in industry. The proposed B.S./M.S. degrees interlace the two programs and automatically provides a strong computational science perspective to students with the core skills of data management, mathematical and statistical modeling, and advanced data analysis.

B.S./M.S. - Applied Math/Computational Finance
B.S./M.S. - Applied Statistics and Actuarial Science/Computational Finance
B.S./M.S. - Computational Math/Computational Finance

Description
The M.S. in Computational Finance program offers a unique opportunity for students in the B.S. programs of Applied Mathematics, Applied Statistics and Actuarial Science, Computational Mathematics to enhance their education and better prepare them for academia or employment opportunities in industry. The proposed B.S./M.S. degrees interlaces the two programs and addresses a vital and growing market niche, a demand for persons with a background in quantitative finance. The programs provide the mathematical foundation for using complex financial models, provide knowledge of financial markets and institutions, and stress financial applications that have their base in statistics and mathematics but involve extensive use of computational methods generally and data mining methods specifically.

B.S./M.S. - Physics/Physics

Description
We propose a new B.S./M.S. program in Physics/Physics. The proposed program is a natural fit that builds on and maintains the strength and rigor of the existing Physics B.S. by adding a pathway into our new Master's in Physics. This will enable qualified students enrolled in our undergraduate program who have interests in furthering their physics training with the attractive option of pursuing either a research or professional M.S. degree, preparing them for careers in the private sector, government, or academia that require more advanced analytical and problem-solving skills, or for embarking on further graduate study at the PhD level.

B.S. PROGRAMS

BS - Integrated Science (with required minor tracks)

Description
Today, science impacts almost every aspect of society. It is at the core of every major innovation that has occurred within the past few decades. The value of entrepreneurial and multi-disciplinary approaches has been confirmed repeatedly. We propose to build upon existing expertise and excellence in RIT's five main science disciplines and in other RIT colleges to create a BS degree program in Integrated Science *with required minor tracks selected from a collection of areas such as Engineering, Entrepreneurship, Business, Marketing, Finance, Computing, or Design*. The program will provide talented undergraduates with an opportunity to pursue studies that go beyond the traditional major in a single field of science. The Integrated Science program breaks down traditional disciplinary barriers and provides students with preparation in any of the core scientific disciplines while adding an array of relevant minor track options, such as entrepreneurship, business, marketing, finance, computing, or design, that prepare the students for exciting careers. The demand for students with this type of integrated BS degree is clearly validated by the continued success of similar programs around the country.

Proposed Programs: The initial proposal has to nucleate a BS degree program in integrated science with ninor in entrepreneurship. The program proposal for a BS in Integrated Science and Entrepreneurship has already been designed and has received unanimous approvals from the college curriculum committees, RIT's Institute Curriculum Committee (ICC) and the Academic Senate. We are proposing a minor modification of that proposal that would make the entrepreneurship part of the program to be a minor or a track. We would then expect to begin to develop other minors and tracks to the BS program.

Why RIT: RIT is uniquely positioned to expand its existing strengths and reputation in applied sciences into this area that, while new to RIT as an academic program, is very popular amongst both local employers and RIT students. Continued employer inquiries and interest, combined with success demonstrated by a growing list of universities nationwide that offer this degree, indicate that graduates of the program will have a strong potential for employment opportunities upon graduation. It is also intrinsically multidisciplinary and experiential, a differentiator for RIT's future.

Prospects for Graduates: Local companies including Alaris, the R&D spinoff of Kodak, continue to inquire about the program. They have voiced interest in hiring the first cohort directly after graduation, demonstrating that the graduates will be highly sought in technology industries. We anticipate no issues in placing all graduates.

Incremental Hires and Space Requirements
Existing Faculty: A recent proposal identified at least 30 faculty across the two initial founding Colleges (Science and Business) who will make meaningful contributions to new Integrated Science program. The interest and enthusiasm across campus and across the local business community is strong.

Incremental Faculty: Although no initial incremental faculty are requested, we envision about two additional junior faculty hires to ramp up the B.S. program when approved. Ultimately one of these would serve as program director. Existing RIT faculty would remain active collaborators. We anticipate the need for 1000 sq. ft. of research space necessary to support new junior faculty.

B.S. – Data Analytics

Description
Data Analytics is an interdisciplinary field about processes and large systems to extract knowledge or insights from data in various forms. It incorporates many fields of study to include mathematics, statistics, and computer science and employs techniques such as data visualization, data mining, and predictive analysis to help aid decision-making. We propose a distinctive, robust and interdisciplinary B.S. program in Data Analytics in which students will work at the intersection of science and engineering to study data mining, visualization tools, database development and data engineering for applications related to health care, imaging science and industry. The purpose is to prepare students for graduate studies in data science and/or data analytics.

The program will address growing global demands for individuals with training in all areas of data science. Whether the need is to crunch large volumes of numbers, allocate time and resources around processing the importance of lots of operational and customer data or engineer data streams to facilitate an analysis from different data repositories, professionals with these skills are highly sought after. It will include potential courses in computer science, geographic information systems, statistics and mathematics just to name a few.

Some core courses and electives for this program would most likely already be in place and we can utilize these strengths within the program. The program would also support and provide students for the M.S. in Data Science already in motion at RIT. We already have a plan for an immersion in Data Science at the Undergraduate level with its first course running in 2018-2019. A formal proposal for a B.S. program in Data Science is planned to be submitted in 2019 in anticipation of the first students beginning in the fall of 2021.

Incremental Hires and Space Requirements
We anticipate the proposal will request to grow the number of faculty by three to support the new program. We also anticipate the need for office space for these new faculty. We anticipate the need for 3 incremental tenure-track faculty (capable of sustaining funded research and teaching advanced courses). We anticipate total incremental space needs of 1800 sq. ft. to include 500 sq. ft. for each of 3 faculty research labs and 100 sq. ft. for each of 3 faculty offices.

B.S. - Machine Learning

Description
Artificial intelligence, and especially machine learning, is now rivaling or exceeding humans at solving real-world problems such as diagnosing disease, recognizing objects, face identification, and much more. Nations and companies are investing billions of dollars in this space, and the

number of US jobs requiring machine learning skills have grown 4.5 times over the past four years. The global market for AI continues to increase, with the supply of capable employees being far lower than demand. Currently, it is difficult for companies to find employees with a machine learning skill set without a PhD. However, all of the basics can be taught in a focused undergraduate program, and other universities are starting to offer these degrees. Such degrees will be commonplace in 10 years, and the College of Science believes we should take the initiative to become leaders in producing students with the skills to apply machine learning to solve scientific problems.

The core of a Machine Learning B.S. degree would be a combination of statistics and mathematics and 2-3 computer science courses. The degree would consist mostly of existing COS courses, including multivariate calculus, linear algebra, discrete math, probability, high-dimensional regression, statistical learning theory, computer vision, and deep learning. It would also include courses in computer programming, data structures, and algorithms. Elective courses may include general artificial intelligence, natural language understanding, dataset analysis and collection, applied AI, control and robotics, and reinforcement learning, many of which already exist at RIT.

The curriculum would overlap partially with the Applied Statistics degree, but it would have greater emphasis on programming, using large-scale non-linear models (e.g., deep neural networks), and problems in machine perception (natural language understanding and computer vision), which are powered using machine learning. Novel versions of existing courses will enable them to focus on machine learning, e.g., probability theory for machine learning.

B.A. PROGRAMS

B.A. - Applied Cognitive Neuroscience

Description

What: Applied cognitive neuroscience uses the results of traditional cognitive science and neuroscience research, along with the tools of mathematical modeling and computation, to understand behavioral processes and create technological advances. We propose to build upon existing expertise and excellence in behavioral and cognitive neuroscience of perception to create new programs in Applied Cognitive Neuroscience. Cognition refers to mental action or processes of acquiring knowledge through the senses and through experience or thought. Neuroscience encompasses any or all of the sciences that deal with the structure or function of the nervous system and brain. RIT has a long history of high-impact research in perceptual neuroscience, in particular with respect to human visual perception.

RIT Focus/Niche: RIT's existing strengths in applied cognitive neuroscience are in the areas of human visual perception. We see this is a starting point, that could readily be expanded to further mathematical and computational models, to other species, and to other aspects of cognitive neuroscience. We see RIT's niche as one of collecting human psychophysical data, performing mathematical/computational modeling and creating engineering solutions to real world problems. The new program will need an office a roughly 1000 square feet of lab space for each of the 4 incremental hires and the same (office + lab) for a program director as well as an administrative office for the program. (5,500 sq ft total).

Proposed Programs: A minor in Applied Cognitive Neuroscience has already been designed and is starting its way through approval processes. We see the next step is to immediately begin development of a B.A. program with existing RIT faculty and a goal to hire some dedicated faculty as the program is implemented. We would then expect that group to begin long-term proposals for M.S. and Ph.D. programs while we seek additional faculty.
Why RIT: RIT is uniquely positioned to expand its existing strengths and reputation in applied sciences into this area that, while new to RIT as an academic program, is very popular amongst students and has strong potential for employment opportunities upon graduation. It is intrinsically multidisciplinary, a differentiator for RIT's future.

Prospects for Graduates: Graduates will be highly sought in technology industries involved with human-computer interaction. These range from smartphones, to VR goggles, to natural language interfaces and many more. Some students will also continue to graduate school in a variety of fields. We anticipate no issues in placing all graduates.

Incremental Hires and Space Requirements
Existing Faculty: A recent proposal identified at least 30 faculty across at least 6 RIT colleges who could make meaningful contributions to new programs in Applied Cognitive Neuroscience. The interest and enthusiasm across campus is strong.

Incremental Faculty: We envision about 4 junior faculty hires to ramp up the B.S. program when approved. We anticipate these faculty would each require 400 sq. ft of lab space and 100 sq. ft office space for a total of 2000 sq. ft. They would also begin proposal planning for graduate programs. At that point, another group of faculty would be sought to fully implement the graduate programs and high-level research. Existing RIT faculty would remain active collaborators.

Proposed Development of B.A. Options for Existing COS B.S. Programs

RIT GenEd: The current RIT General Education Framework requires 60 credit hours as follows:

First-Year Writing	3
Perspectives	24
Immersion	9
Gen Ed Electives	24

B.S. Programs: The NYSED B.S. program requirements are for a minimum of 120 credit hours with 50% of those credits in Liberal Arts & Sciences (60 credit hours LAS minimum).

A typical RIT B.S. program includes 60 credit hours LAS (some might be required by major, a practice that can reduce flexibility) and 60 credit hours for the major (with 6 free elective). The use of the general education framework for required program courses appears to violate the spirit of NYSED regulations, but not the letter.

B.A. Programs: The NYSED B.A. program requirements are for a minimum of 120 credit hours with 75% of those credits in Liberal Arts & Sciences (90 credit hours LAS minimum).

The proposed typical RIT COS B.A. program would
include: 60 credit hours LAS (RIT Framework)
30 additional credit hours LAS electives (e.g. two minors, or second major in LAS area) 30 credit hours major program (in LAS or other area)

B.A. Benefits: With such programs it becomes very easy to double major as long as at least one major is within LAS. Other benefits include:

- Far easier to change majors
- Much more flexible
- Better retention (B.S. to B.A. no loss in time to graduation).
- Could easily have a common first year of LAS courses with some exploration
- Science exploration students could transition more smoothly
- Probably enhance recruitment (flexibility, more like "other" universities)

Incremental Hires and Space Requirements
Incremental Faculty: Incremental faculty would only be needed if/when the B.A. programs are successful in increasing the overall COS majors enrollment and retention.

Note: Existing COS B.S. programs could accomplish this flexibility by reducing the major program requirements to 30 credit hours and leaving 30 credit hours as free electives. Students could use those electives to either broaden or deepen their program with appropriate advising.

APPENDIX B: COS 10-YEAR RESRACH AREAS/PROGRAMS MASTER PLAN

HARNESSING THE DATA REVOLUTION [UMBRELLA]

Data Science and Data Analytics
Data science is used to discover patterns and make predictions from massive amounts of data. This need is pervasive across industry, government, and academia, and it is fueled by real-world problems in a wide variety of disciplines. Researchers in this area create and apply new, cutting-edge techniques to collect, transform, model, and visualize data. Data science and statistical machine learning research touches upon business intelligence, astrophysical inference, criminal justice, sustainability and energy economics, imaging science, medicine, politics and civic engagement, higher education and student success, industrial internet of things (IIOT), and sports analytics.

Mathematical Modeling
Mathematical modelers uses mathematics, logic, and computing power to represent complex real systems and to predict future behaviors or results that are as yet unseen or unmeasured. Every mathematical modeling enterprise has four aspects: the content of the application field, the mathematical formulation and analysis, the analytical and computational methods, and the interpretation and analysis of the results. Mathematical modeling is as essentially collaborative as it is innovative. Consider the cardiovascular modeling work that is being done by researchers in the School of Mathematical Sciences (SMS). It involves mathematicians, cardiologists, computer scientists, veterinary scientists, physicists, statisticians, biomedical engineers. Or consider the contact lens and tear film modeling, also in SMS: applied mathematicians are collaborating with optometrists, mechanical engineers, rheologists, and physicists. Similarly, pharmacological modeling of cell-signaling pathways is done by teams of mathematicians, biochemists, chemical engineers, and computer scientists.

Bioinformatics
Bioinformatics is at the interface between biotechnology and the computing sciences. The research foci are geared towards developing and employing computer software to parse, analyze, organize, and visualize biological data ("big data") to facilitate new discoveries in areas such as; agriculture, biomedical research, comparative genomics, genomics, molecular imaging, pharmaceutical research/development, proteomics and the understanding and elucidation of diseases (i.e. cancer etc.).

THE QUANTUM REVOLUTION

Exploiting quantum mechanics to observe, manipulate, and control the behavior of particles and energy at atomic and subatomic scales, resulting in next-generation technologies for sensing, computing, modeling, and communicating.

Materials Science
Materials science is essentially the application of chemistry and physics to predict, create, characterize, and optimize matter in novel states or combinations that are useful for applications. Across COS, and RIT more broadly, we presently have strengths in electronic and photonic materials; energy storage systems; correlated materials; organic electronic materials; polymers; and catalysis.   Materials science research at RIT may extend to nanotechnology, semiconductors, optics, lasers, sensors, porous materials, light emitting materials, ceramics, biological materials, magnetic materials, thin films, colloids, organic and inorganic photovoltaics; batteries and supercapacitors; fuel cells; hydrogen generation and storage; thermoelectrics; catalysis; solar fuels and thermosolar power; magnetocalorics; piezoelectrics.

Quantum Information
Established and emergent technologies rely upon quantum interference and quantum entanglement for their cutting edge performance characteristics. Energetic and highly varied current research activity focuses on solving technological and theoretical challenges within the fields of quantum information processing (interpreted broadly to include quantum computing, quantum cryptography, and quantum communication), quantum sensing, quantum imaging, and quantum metrology. Two of the leading architectures for quantum systems are (1) photons and (2) atoms/ions.

Molecular Quantum Mechanics
The study of Quantum Chemistry and Molecular Quantum Mechanics reflects a crucial and ongoing quest to apply extraordinarily accurate fundamental laws to gain a quantitative understanding of the origins of molecular structure, reactivity, catalysis, and intermolecular forces. This will impact research in chemical and soft-matter physics, condensed matter physics. Profound advances in quantum-mechanical density functional theory have spearheaded a transformation of many parts of quantum chemistry, molecular quantum mechanics, and materials science. In biology and biochemistry, quantum mechanics has been undergoing rapid growth in catalysis, electron transport, photosynthesis, and vision, and in developing more quantitative knowledge of intermolecular interactions including dispersion, induction, and electrostatic forces. This emergent area will be crucial to developing predictive and quantitative physical theories of the roles of mutations in altering interactions between molecules that can affect physiology, disease, and evolution.

COMPLEX SYSTEMS SCIENCE [UMBRELLA]

Complex systems are made up of large collections of interconnected components whose interactions, and often self-regulation, lead to "behavior" at a more macroscopic level. For example, such systems include: Biological systems (e.g. genetics, bio-materials, ant colonies, slime molds, fungal organisms), Astronomical systems (e.g. computational gravitation, planet formation, astrobiology), neural systems (e.g. brain dynamics, perceptual physiology, neuronal modeling, cognition/perception), Physiological systems (e.g. ocular tear film, cardiac arrhythmias, cancer cell behavior) Physical systems (e.g. modern materials, plasma science, optics and photonics), Earth systems (e.g. climate change, forest fires, earthquakes, hurricanes), Social systems (e.g. transportation networks, environmental policy, economy), and Information systems (e.g. networking, high-performance computing, bioinformatics, imaging systems). Complex Systems Science aims to understand how to measure, predict, and/or control the more macroscopic behavior or performance of these complex systems that can have significant global impact on our natural and man-made worlds.

Applied Cognitive Neuroscience

Applied cognitive neuroscience uses the results of traditional cognitive science and neuroscience research, along with the tools of mathematical modeling and computation, to understand behavioral processes and create technological advances. Cognition refers to mental action or processes of acquiring knowledge through the senses and through experience or thought. Neuroscience encompasses any or all of the sciences that deal with the structure or function of the nervous system and brain. RIT has a long history of high-impact research in perceptual neuroscience, in particular with respect to human visual perception. We propose to build upon existing expertise and excellence in behavioral and cognitive neuroscience of perception to create new programs in Applied Cognitive Neuroscience.

Vision

Vision research aims to understand the human visual system and how it is used to help us perceive and interpret information from images and the environment. We aim to understand high-level visual perception; how humans extract information from images and the environment, and how that information is used in decision-making and to guide actions. Further aims include bettering our understanding of the mechanisms that allow humans to perform everyday visually guided actions leveraging advances in virtual reality and motion capture technologies that afford both freedom of movement, and a naturalistic visual experience. Additional vision-related work uses machine learning to solve problems in computer vision.

Color Science

Color science is intrinsically multidisciplinary and involves the scientific study of all aspects of color from the physics of light, to the physics and chemistry of light-matter interactions, to the anatomy, physiology, and psychology of human perception. The Munsell Color Science Laboratory (MCSL) has a track record of being one of the world's preeminent academic laboratories dedicated to color science research and education. Current research areas include: Visual Perception; Appearance in Augmented Reality/Virtual Reality; Cultural Heritage Imaging and Reproduction; 3D Printing; Psychophysics; Dynamic Lighting; Fuzzy Logic Modeling; Spectral Imaging; HMD Color Characterization; Perception While Driving.

Earth Systems Science

Fundamental and Applied Earth Systems Science (ESS) research programs address societal needs in areas related to environmental change, technological change, sociological change, and the intersection of these three domains. Examples of research include: systems modeling; exploitation of imagery; ecological modeling, landscape changes and restoration ecology; food-energy-water systems; ecotoxicology and pollutants; investigation of environmental systems' response to climate change; invasive species, and land use/cover change; "anthropogenic" factors, e.g., resilience and restoration of ecosystems and infrastructure, agriculture and food systems, energy and transportation systems, persistent and emerging contaminants, and natural-human interactions. Intersectional collaborations are possible with areas such as sustainability, computer science, and public policy.

Discipline-Based STEM Education

Discipline-based education research (DBER) blends research on learning and cognition with a deep disciplinary grounding, generating insights that can be used to better educate students and advance our theoretical understanding of STEM teaching and learning. Current research areas include: how student identities and perceptions, particularly those of excluded identity groups, shape their experience within the academic environment; increasing the alignment between academic and workforce discussions of STEM; how students interpret key concepts to both increase pedagogical effectiveness and reveal new insights in student thinking; identifying barriers to improving pedagogy and environment and developing of assessments to measure the impact of change efforts.

LIVING SYSTEMS, MACRO AND MICRO [UMBRELLA]

Environmental Science

Current research in this area focuses on power generation, waste reduction and recycling, pollution control, land use and land cover change, preserving biodiversity and ecological services, transportation, forestry, agriculture, economics, and a wide range of other areas. In addition, relationship to nature, developing solutions that prevent or reverse environmental deterioration and work toward sustainability is also of great interest. The discipline is a transdisciplinary field that requires problem-solving abilities based in science, mathematics, the social sciences, and other disciplines.

Biotechnology/Biochemistry

Current research focuses on the biochemistry and molecular biology of disease processes, bioanalytical methods and computational biochemistry, creation and characterization of multimodal agents for imaging disease processes; structural biology focusing on protein and nucleotide structure/function, antibiotic/biocide development, bacterial communication, agriculture, virology, plant pathology and bioremediation.

Food and Agriculture

The current world population of 7.6 billion is expected to reach 8.6 billion in 2030, 9.8 billion in 2050 and 11.2 billion in 2100, according to a recent report from the United Nations. Improving the production and protection of food will be necessary to suffice the growing population. The goal of this research area is to enhance the research thrust in the COS specifically as it relates to precision agriculture, pre/post-harvest physiology, and protection of crop plants. It should be noted that the COS currently has a core group of research faculty in the Chester F. Carlson for Imaging Science and the Thomas H. Gosnell School of Life Sciences that are active in this area. In addition, this research area is aligned with the institute’s plan to secure a farm, construction of a new greenhouse in the COS and the recruitment of additional research faculty leveraged by the COS genomics initiative.

Biomathematics
The aim of those that study biomathematics is to bring much-needed quantitative skills to bear on important physiological problems. Academic and industrial research addressing challenges such as understanding the behavior of complex organs, characterizing cell-signaling pathways, identifying biophysical causes of diseases, developing personalized medical treatments, and making better use of clinical data will benefit from a network of well-trained mathematical researchers. Examples of biomathematics research include: modeling cardiac arrhythmias; improving contact lens function and fit; characterization of the liquid structure of bioproteins; improve the assessment of tumor growth through advanced image analysis techniques.

Biophysics
Biophysics is an interdisciplinary science that seeks to uncover and understand the fundamental physical principles, processes, and mechanisms that underlie emergent form and function at all levels of biological organization—starting from molecules to cells to tissues to organs to organisms to population levels. Biophysicists use experimental, analytical, and computational approaches and methods of Physics to study living systems as well as synthetic systems that mimic certain desired properties of biological systems and materials.

IMAGING SCIENCE [UMBRELLA]

Imaging Science is an interdisciplinary field of study that investigates novel imaging systems and their application across a wide range of science and engineering domains. Research areas include remote sensing through airborne or space-based imaging systems, human and computer vision systems, optical imaging system development, nanoimaging, and cultural heritage imaging.

Remote Sensing
We conduct remote sensing research focused on imaging the earth's environment in the visible, near infrared, and thermal infrared spectral regions. We use modeling tools, field measurements, and synthetic image generation to understand how remotely sensed data can be used to study environmental processes and provide security. Research focuses on the development of tools to extract information about the earth from aerial and satellite imaging systems with an emphasis on the application of science and engineering to solving end-to-end remote sensing problems using a systems engineering approach. This includes design and development of imaging instruments, developing algorithms to extract information from remotely sensed systems and measurement and modeling of the physical phenomena associated with the formation of remotely sensed images.

Earth Systems Science
Fundamental and Applied Earth Systems Science (ESS) research programs address societal needs in areas related to environmental change, technological change, sociological change, and the intersection of these three domains. Examples of research include: systems modeling; exploitation of imagery; ecological modeling, landscape changes and restoration ecology; food-energy-water systems; ecotoxicology and pollutants; investigation of environmental systems' response to climate change; invasive species, and land use/cover change; "anthropogenic" factors, e.g., resilience and restoration of ecosystems and infrastructure, agriculture and food

systems, energy and transportation systems, persistent and emerging contaminants, and natural-human interactions. Intersectional collaborations are possible with areas such as sustainability, computer science, and public policy.

Medical Physics and Imaging

Medical Physics and Imaging includes applications of imaging to diagnose disease (e.g., magnetic resonance imaging, and positron-emission or x-ray tomography), imaging to guide the treatment of disease (such as generating precise 3D anatomical models to guide high-risk surgical procedures), therapeutic applications of radiation (photon, charged-particle, or neutron-beam modalities for the treatment of disease), nuclear medicine, and health physics/dosimetry/protection required in radiation environments (e.g., hospitals, nuclear reactor facilities, or large-scale research facilities that generate and utilize radiation).

WINDOWS ON THE UNIVERSE [UMBRELLA]

Gravitational-Wave Physics

The discovery of gravitational waves just ushered in a new kind of astronomy—gravitational-wave astronomy. The success of gravitational wave-astronomy requires observatories that depend on a battalion of experimental and computational physicists and engineers, experts in optics, lasers, signal processing, and much more to develop techniques capable of measuring distances smaller than a thousandth of a proton diameter, and detect true signals in an unforgiving background of seismic, thermal, and laser noise.

Astrophysics

Direct imaging and spectroscopy of extrasolar planets: The world's largest telescopes and radio interferometers can now obtain images and spectra of nearby young planets and their environments. Several new exoplanet detection and characterization missions are in active development or planning stages. Exoplanet studies are among the main science drivers for NASA's new James Webb Space Telescope and the next generation of giant ground-based telescopes and their instrumentation.

Multi-messenger studies of massive compact objects: The recent discoveries of gravitational waves from merging massive black holes and the subsequent detection of simultaneous electromagnetic and gravitational waves signals from a merging pair of neutron stars have ushered in a new era of astrophysics exploration and discovery. The future of this field is coupled to the development of next-generation ground- and space-based gravitational waves facilities such as pulsar timing arrays.

The origin and early evolution of galaxies and galactic structure in the universe: A major science theme of the next generation of giant ground-based telescopes and future NASA flagship missions is the identification and investigation of the first stars, galaxies, and black holes to emerge in the early universe following the Big Bang, from the so-called Dark Ages through the epoch of reionization. Understanding how these first structures formed, and the physical processes that guide their evolution to today's galaxies and galaxy clusters, is one the major open areas of research in NASA's strategic plan.

Space Photonics
Space Photonics is the application of photonics in space-based applications. It includes any device or system that uses photonics, such as telescopes, detectors, photovoltaics, exoplanet-finding technologies, optical communication, photonic circuits, optical propulsion, optical navigation, autonomous docking and landing, etc. This strategic area would have significant impact in human and robotic exploration of space, including the development of instruments for sensing life on exoplanets using low noise detectors, optical nulling technologies, and miniaturized Astrophotonic instruments.