# College of Science

## 2020-26 STRATEGIC PLAN

Virginia Tech

## FROM THE DEAN

Science doesn't exist in silos. It can't. The world's most challenging problems don't contain themselves to neat boundaries — they span industries, nations, and scientific disciplines. If ever there was an example of this, it is the COVID-19 global pandemic that has engulfed the world.

COVID-19 has clearly and unquestionably demonstrated the importance of science to the health and welfare of every human on the planet. It has shown the importance and relevance of science, not only for the betterment of humanity but most fundamentally for its very survival in the face of the worst pandemic since the 1918 Spanish Flu.

Whether in a few months or in a few years, the world will emerge from this challenge. It will do so with the help of science and because of science.

The work on this Strategic Plan began more than a year ago. While the world now seems completely changed, this Plan was written as a long-term path to the future. Via this Plan, the College of Science has plotted a course to become a global leader that provides solutions for today and develops leaders for tomorrow. Our current situation has shown that this is more important than ever.

Specific activities supporting implementation of this Plan will be developed, refined, and executed over the coming years. COVID-19 may require us to slow down implementation in the short term, but we will stay focused on our goals over the long term. As we move forward, we will be purposeful in our implementation and we will use continuous planning to regularly evaluate our progress and adjust as needed.

Please join us on our journey to educate and inspire a new generation of scientists who will change the world.

Sally C. Morton
Dean, College of Science

## OUR VISION FOR THE FUTURE

In the Virginia Tech College of Science, we discover, create, inspire, and inform. We teach. We learn. We explore, advance, and use science to promote healthy living, strong communities, and a sustainable planet. Our research is focused on the future, aimed at discoveries that address the world's most critical problems. We believe in advancing Science as a service to our community, our state, and the world.

The College of Science is committed to tackling today's challenges in ways that make an impact in the real world. Addressing society's needs can only be achieved through a convergence of deep know-how that comes from the fundamental scientific disciplines and a willingness to work together in new ways, with new people, across scientific disciplines.

It takes drive to innovate and courage to disrupt the way things have been before. Within the College, traditional disciplines are being reimagined and recombined because this is the only way to truly understand and address the problems affecting the world.

President Tim Sands recognizes the key role that the College of Science claims at Virginia Tech:

> "*Science was a pillar that supported Virginia Tech's development into the great university that it is today, and scientific excellence is essential for advancing Virginia Tech to even greater heights as we look toward the future.*"

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**VISION**
To be world leaders in transdisciplinary science, grounded in fundamental disciplines, fueled by data, focused on discovery, and directed at decisions.

**MISSION**
We explore, teach, advance, and apply science to promote healthy people, strong communities, and a sustainable planet.

**CORE VALUES**
- **Excellence** in all we do.
- **Discovery** as the key to science and innovation.
- **Hands-on learning** to promote an informed and scientifically literate citizenry.
- **Diversity and inclusion** to create a robust, durable, and thriving scientific community.

The College of Science core values rest on the Virginia Tech motto of *Ut Prosim* and the spirit of a land-grant institution pervades all that we do. Science at Virginia Tech is inherently *Ut Prosim.*

The College also upholds the University's core values of Diverse and Inclusive Communities, Knowledge and Innovation, Opportunity and Affordability, and Excellence and Integrity.

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## An Inclusive and Continuous Planning Process

This Strategic Plan is the result of a year-long effort during which information, opinions, ideas, and data were collected from across the College and all of our stakeholders including faculty, staff, undergraduate and graduate students, alumni, and other external partners. An analysis of the College's strengths, weaknesses, opportunities, and threats provided a strong foundation for our planning efforts. Additional information about the planning process and current state of the College is included in the appendices.

As the COVID-19 pandemic has demonstrated, the rapidly changing landscapes of science and higher education can gradually undermine a static strategic plan over a five-year timeframe. Therefore, this Strategic Plan is intended to be a living document, evolving, adapting, and improving as the College makes progress toward its goals and providing flexibility to seize opportunities as they arise.

Implementation of the Plan will include a continuous planning process that annually assesses progress toward milestones, reviews priorities, and, where warranted, revises and realigns goals and activities. Execution of these activities may include ad-hoc Task Forces that can nimbly analyze issues of immediate priority and make recommendations. Task Forces will be broadly representative and conduct their reports in an open and transparent fashion.

## Strategic Priorities and Goals

In this Strategic Plan, we describe four transformational Strategic Priorities that collectively define our path forward as we reimagine our future and our continued commitment to scientific excellence.

The College of Science will:

I.   *Be a global leader in fundamental and transdisciplinary scientific research, discovery, scholarship, and education.*

II.  *Continue to build a robust, durable, diverse, inclusive, and thriving scientific community focused on excellence.*

III. *Excel in outreach, engagement, and economic development to promote healthy people, strong communities, and a sustainable planet.*

IV.  *Invest in the College's people and infrastructure to fully support our missions of teaching, research, and service.*

As shown in the ensuing pages, each of the four Strategic Priorities have three associated Goals and four to six possible Supporting Activities to guide implementation. A subset of these or similar types of activities will be selected each year via an annual implementation plan that will set out specific goals, metrics, milestones, and responsible parties.

## Initial Initiatives

While the University and College will likely be facing some challenging budgetary pressures over the next few years as a result of the COVID-19 pandemic, our vision for the College of Science remains clear. We will continue to support, develop and promote our greatest asset: the faculty, staff and students of the College. To start, we will focus on those initiatives in our Plan that best position the College for success, including:

- **Create an Academy of Data Science**. The need for methodological developments in Data Science and the education of all scientists and science students in Data Science has never been greater. The Academy of Data Science will encompass the College's focus on Science – it will include both the science of Data Science, as well as the use of Data Science in Science. We believe it is essential to consider Data Science as a science in its own right, as well as an essential component of any scientific discipline.

- **Invest in High-Impact Strategic Research Opportunities**. The College of Science will continue to invest in and promote research opportunities that are aligned with these strategic priorities, such as the projects listed in Appendices E and F, with particular emphases on advancing regional, national, and global impact. In the short term, these research efforts include coastal resilience, quantum information science, cryptography, and others, including COVID-19. In addition, the College will continue to invest in faculty research via the Dean's Discovery Fund, the new Academy of Data Science, and other avenues.

- **Expand Our Educational and Research Excellence**. The College has a wide range of academic programs, both undergraduate and graduate, many of which are growing, along with a structure that promotes both disciplinary depth in fundamental science and transdisciplinary breadth that connects departments and expands research collaborations. We will continue to develop those mechanisms as well as degree offerings and certificate programs, including in the Greater Washington, D.C., Metro Area and particularly on the Innovation Campus.

- **Develop a Top-notch Women in Science Leadership Program**. The College will establish leadership programs for Women in Science as a way to both advance diversity in science and as a way to distinguish our College and our programs from competitors. In so doing, we will establish the Virginia Tech College of Science as a destination for faculty, staff, and student talent from across the country and around the world, and we will become the premier organization for the development of scientific talent.

## STRATEGIC PRIORITY #1

*The College of Science will be a global leader in fundamental and transdisciplinary scientific research, discovery, scholarship, and education.*

➢ **GOAL 1:** Expand the depth and breadth of science scholarship, focusing on research excellence, and increase the impact of research and discovery in the College of Science.

➢ **GOAL 2:** Enhance basic research and disciplinary areas of distinction, while simultaneously building transdisciplinary research capabilities and investing in high-impact strategic research opportunities.

➢ **GOAL 3:** Provide cutting-edge, meaningful, transformative, and high-quality educational experiences for all students, including ensuring that non-College of Science students learn to appreciate the importance of science and scientific inquiry.

## Supporting Activities

### GOAL 1: Expand Scholarship and Increase Research Impact

- Grow the College of Science faculty to most effectively conduct research and discovery in the College with a focus on the appropriate balance of tenure-track, research, and instructional faculty, in Blacksburg, Roanoke, and the Greater Washington, D.C., Metro Area.

- Ensure sufficient staff to effectively support and enhance increased faculty and student productivity, while continuing the day-to-day operations of the College.

- Expand philanthropic support for faculty scholarship, including the number and size of endowed chairs, professorships, and faculty fellowships, and increase other forms of philanthropy that enhance departmental operations and research facilities.

- Leverage University award processes and alumni to identify and nominate faculty to receive national awards, disciplinary-specific Fellow appointments and other recognition.

- At the University, College, and department levels, expand promotion of College faculty research achievements via the popular press, professional venues, Virginia Tech media, and other relevant outlets.

- Increase the number of College of Science publications in high-impact journals including *Science, Nature,* and the flagship journals in each College of Science discipline.

## GOAL 2: Enhance Basic Research and Areas of Distinction

- Make selected, significant investments in research areas while continuing to invest in the College's departments, new cross-cutting and transdisciplinary programs and, over time and as resources allow, a selection of the high-impact research opportunities described in Appendices E and F.

- Create a mechanism within the College for teams that are planning to submit large-scale proposals to request limited specific resources to support proposal development.

- Continue the Dean's Discovery Fund, potentially modified in some years (at the Dean's discretion) to focus on particular research area(s) in order to promote the visibility of certain topics and/or to establish a critical mass of research in that area.

- Capitalize on State and University investments in the Commonwealth Cyber Initiative, Innovation Campus, and other research initiatives to engage in transdisciplinary research.

- Establish an interdisciplinary organization within the College that facilitates collaboration among faculty and students in data science methods, that provides expertise in the application of data science methods to science and scientific problems, and that will be a key research resource.

- Continue to increase and deepen internal collaborations with other Colleges to increase impact across research and discovery, teaching and learning, and outreach and engagement.

## GOAL 3: Provide Transformative Educational Experiences

- Support and encourage revised curricular offerings at both the graduate and undergraduate level, especially in new cross-cutting and transdisciplinary areas, ensure that all College of Science students graduate literate in data science methods applicable to their field and role as informed citizens, and provide interested students with avenues to extend their skills and knowledge.

- In partnership with Career Services, promote and expand externship and internship opportunities for College of Science students and continue to offer and expand the College of Science Career Fair.

- In addition to imparting discipline-specific knowledge, ensure that College of Science courses taught to students of non-science majors are appropriately designed and taught so that all students learn to appreciate the importance of science and scientific inquiry. For example,

consider reimagining the Math Emporium to best meet the pedagogical and curricular needs of today's students.

- Ensure that College of Science service courses are meeting the needs of non-College of Science majors through enhanced communications and enhanced processes for enrollment with other Colleges and their faculty.
- Support and encourage innovative teaching; apply new technologies and pedagogies to best meet the needs of today's students, including taking full advantage of year-round academic sessions.

## STRATEGIC PRIORITY #2

*The College of Science will continue to build a robust, durable, diverse, inclusive, and thriving scientific community focused on excellence.*

- ➢ **GOAL 1:** Enhance our ability to attract, hire, and retain the best faculty, staff, and students from around the world, with an emphasis on improving the diversity of the College of Science in all dimensions.
- ➢ **GOAL 2:** Increase the number of women, underrepresented, first generation, and historically disadvantaged students, to more closely align College of Science undergraduate student demographics with the Commonwealth's, and establish processes to support their success.
- ➢ **GOAL 3:** Promote a culture focused on excellence in all that we do – teaching & learning, research & discovery, and service & outreach – recognizing that a diverse and inclusive environment is the foundation upon which excellence in science is built.

### Supporting Activities

**GOAL 1: Attract and Retain the Best Faculty, Staff, and Students**
- Strongly support Virginia Tech meeting the following University Strategic Plan goals:
  - "Achieve progress in competitive faculty salaries towards 50th percentile of top 20 Research (R1) Public Land-Grant Universities by 2024."
  - "Achieve progress in competitive administrative and professional faculty and staff salaries towards the 50th percentile of relevant market range by 2024."
- Improve the College's attractiveness to prospective graduate students by increasing stipends to be competitive with our peers, expanding the

availability of graduate research assistantships, and strongly supporting the establishment of Ph.D. candidacy status with a reduced tuition rate.

- In collaboration with University Human Resources, gather insights from current College staff to more comprehensively understand and improve the College's attractiveness to prospective staff including compensation, professional development, career progression, and work autonomy.

- Recruit and retain faculty, staff, and students with varied backgrounds and life experiences as a foundation for scientific excellence and to enhance College and departmental diversity in all dimensions and at all levels.

- Continue to create and enhance a welcoming, inclusive community in the College and our departments, and an environment of equity and inclusion in which everyone feels welcome and can thrive.

- Develop a top-notch Women in Science leadership program and curriculum for faculty, staff, graduate students, and undergraduate students; establish Virginia Tech as the destination for women interested in science.

## GOAL 2: Build and Sustain a Thriving, Inclusive, and Diverse Undergraduate Student Population

- Coordinate with Admissions to increase recruitment of women, first generation, underrepresented, and historically disadvantaged students.

- Develop an enrollment plan in collaboration with Enrollment Management to improve the student diversity applicant pool and expand access and opportunity that will increase enrollment in key College of Science majors.

- Promote student growth and success in College of Science majors while maintaining the rigor and excellence of curricular offerings by identifying and addressing factors that become obstacles in student retention, progress to degree, and overall success in programs.

- Identify barriers to increase the success rates of historically disadvantaged students, first generation students, transfer students, and student populations with special needs; create support networks and programming and, in partnership with other offices around campus, implement measures to improve success.

- Expand professional academic advising in the College to improve the undergraduate experience, promote student success, integrate advising throughout student experiences, and support faculty focus on pedagogy and research.

### GOAL 3: Enhance Our Culture of Excellence

- Promote the growth and nurturing of faculty to produce excellence by increasing the number of endowed faculty positions.
- Expand the number of faculty who are members of the National Academies, Fellows in the American Association for the Advancement of Science, and Fellows in the professional organization(s) of each College of Science discipline.
- Increase the number of College of Science faculty serving on National Academies and equivalent panels, and conducting similar high-visibility, high-impact national and international service.
- Leverage the Sowers Lecture Series and similar department-level seminar and lecture series to raise the national and international visibility of the College of Science, our departments, and our faculty.
- Implement and operationalize the responsibility for promoting faculty recognition in both research and teaching through national and international award nominations as a primary function of the College Honorifics Committee and departmental honorifics committees.
- Promote the growth and development of staff by making career advancement and professional development resources readily available and promote the recognition of staff accomplishments through College and University level awards, such as the College of Science Outstanding Staff Award, the President's Award for Excellence, and others.

## STRATEGIC PRIORITY #3

*The College of Science will excel in outreach, engagement, and economic development to promote healthy people, strong communities, and a sustainable planet.*

- ➢ **GOAL 1:** Establish partnerships with alumni, industry, the public, and local and national policymakers in order to increase the impact of our research, improve the visibility of our faculty and students, and promote societal well-being.
- ➢ **GOAL 2:** Enhance the College's outreach and engagement activities to promote science and scientific literacy, increase awareness of Virginia Tech and the College of Science, and attract the best and brightest faculty, staff, and students to the College.
- ➢ **GOAL 3:** Support economic development in the Commonwealth, particularly related to the University's efforts in Roanoke and the Greater Washington, D.C., Metro Area, with an emphasis on the College's

strengths in basic science, applied science, data science, and decision science.

## Supporting Activities

### GOAL 1: Establish External Partnerships

- Promote external collaborations and develop strong and enduring partnerships with industry, other universities, government agencies, national laboratories, and alumni to address grand societal challenges.
- Continue to coordinate with LINK, LICENSE, & LAUNCH (VT Centers for Advancing Industry Partnerships, Technology Commercialization, & New Ventures) to expand the College's corporate partnerships in research collaborations, corporate giving, and technology transfer and commercialization.
- Promote a culture of innovation and entrepreneurship that expands opportunities for faculty, both in terms of research commercialization and external research collaborations, all while protecting faculty and University intellectual property.
- Increase alumni and College of Science Roundtable involvement in order to enhance the College's visibility and reputation, to engage their expertise, passions, and interests in College activities, and to leverage their formal and informal communication resources as individuals and as employers.
- Establish an emerging leaders alumni council for the College of Science to continue to engage diverse groups in the activities of the College and to help the College serve our recent alumni from emerging and strategic programs.

### GOAL 2: Enhance Outreach, Engagement, and Scientific Literacy

- Expand the College's outreach and engagement activities to include conducting additional science camps, targeting outreach to high schools and underrepresented groups, expanding teacher professional development opportunities, and participating in K-12 school events with a focus on STEM programs and initiatives.
- Conduct Research Experience for Undergraduates (REUs) or other summer research programs for undergraduate populations and consider conducting "pre-REUs" (6-week programs for freshmen/sophomores) focused on mathematics, physics, and other quantitative skills.
- Encourage departments and faculty to showcase the College of Science via conferences and workshops organized on campus.

- Evaluate starting a Meyerhoff Scholars-like program in the College to nurture diverse Science leaders, perhaps with an associated summer bridge program as a pre-college experience in the summer before students' first year.

### GOAL 3: Support Virginia's Economic Development

- Develop and grow professional education, including degree offerings and certificate programs, in the Greater Washington, D.C., Metro Area, including the Data Analysis and Applied Statistics M.A. and a new transdisciplinary M.S. in Data Science, and develop a professional M.S. in Biostatistics to be offered on the Roanoke Campus.
- Expand participation in the Commonwealth's Higher Education Package to include having a College of Science presence on the Innovation Campus; continue to seek inclusion of relevant College programs in the Higher Education Package.
- Encourage a culture of innovation to support economic development in the Commonwealth, including under the Rural Virginia Initiative, and promote collaborative research that fosters discovery and enables innovation in business, education, engineering, and all sciences.
- Increase partnerships with industry and government in the Greater Washington, D.C., Metro Area to develop and strengthen the scientific workforce pipeline, to include areas such as regulatory science, drug approval, and government decision making.

### STRATEGIC PRIORITY #4

*The College of Science will invest in the College's people and infrastructure to fully support our missions of teaching, research, and service.*

- ➢ GOAL 1: Support and encourage the professional development, career satisfaction, and work-life balance of College of Science faculty and staff so they may reach their full potential, maximize their quality of life, and make the College a destination for new talent.
- ➢ GOAL 2: Develop and expand the College's financial resources, including maximizing revenue returned to the College under the Partnership for an Incentive-Based Budget (PIBB), in order to support College operations via robust funding and other assets that are resilient to external influences.
- ➢ GOAL 3: Improve the quality and quantity of College facilities and infrastructure to best support faculty teaching and research

productivity, including the establishment of affordable shared research facilities to promote research excellence and financial efficiency.

## Supporting Activities

### GOAL 1: Support Faculty and Staff Development and Work-Life Balance

- Evaluate College of Science and departmental policies, procedures, and operations to increase faculty and staff satisfaction with career advancement opportunities and work-life balance.
- Provide staff with professional development and career opportunities, with a focus on building and sustaining an inclusive and welcoming environment and a culture of excellence. Promote and encourage staff involvement in the life of the University.
- Provide faculty with professional development opportunities, including an expansion of the College of Science Faculty Academy as a way of helping new faculty efficiently establish their research programs and be successful members of the faculty. Work with the Office of the Provost to establish an equivalent program for mid-career faculty.
- Create mechanisms for faculty to gain experience in data science methods relevant to their field(s) of research via College-wide seminars, guest lectures, mini-courses, and other educational means

### GOAL 2: Develop Financial Resources

- Eliminate the $2.1 million instructional gap (which represents the difference between the College's base budget for graduate teaching assistants and tuition remissions, and the actual cost of supporting these positions) in order to balance the College's budget.
- Identify new resources to relieve persistent budget pressures, for example via increased course and lab fees, implementation of a College-wide program fee, and a variety of extramural funding sources including increased philanthropy, as well as ensuring that the College is fully funded under the PIBB.
- Expand enrollment in smaller majors, including Economics, Geosciences, Nanoscience, Statistics, and Systems Biology; successfully implement and grow the Behavioral and Decision Science major; and create economies of scale in the Computational Modeling and Data Analysis programs in order to increase enrollment in cost-effective ways.
- In order to maximize revenue under the PIBB, establish processes and metrics to monitor overall College performance and coordinate and assess departmental performance.

### GOAL 3: Improve College Facilities

- Advocate for and help support the Office of the Vice President for Research and Innovation's efforts to establish shared research facilities, particularly expensive facilities in high demand by College of Science faculty, along with a feasible financial structure that is affordable for Principal Investigators.

- Strongly advocate for the University to address the substantial deferred maintenance and older buildings that require funding to maintain and restore, particularly Derring, Hahn, McBryde and Robeson Halls and other such facilities that hinder faculty recruiting, retention, and the conduct of research.

- Successfully operationalize the Undergraduate Science Lab Building and the Data & Decision buildings in order to provide additional teaching laboratory space and other facilities for College faculty. As the University and the College continue to grow, continue to advocate for essential new faculty office and lab space.

- Coordinate with the investment and thematic institutes in areas of synergy in order to maximize their effectiveness while creating research and other opportunities for College faculty.

## KEY MEASURES & MILESTONES

This Strategic Plan consists of four Strategic Priorities, each with three associated Goals, and four to six possible Supporting Activities. For the College's purposes, it would be unwieldy and impractical to establish one or more measures with milestones for every supporting activity, particularly since the College views most of the University Strategic Plan metrics as directly or indirectly applicable to the College.

The College of Science strategic plan is well-aligned with the Virginia Tech Strategic Plan metrics and milestones and the PIBB metrics, and focuses on a small set of additional key measures and long-term milestones that are crucial to the College's future success.[1] Success in achieving these milestones will be transformational for the College, focus on investment in our people, and represent the unique contribution the College can make to the University.

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[1] These measures, like the University Strategic Plan milestones, are designed to follow the principles in "Metrics White Paper: On the Design and Use of Metrics" (https://strategicaffairs.vt.edu/content/dam/strategicaffairs_vt_edu/Appendix%20B%20Metrics%20Rankings%20PIBB.pdf)

| Strategic Priorities & Goals | Measures | Milestones |
|---|---|---|
| **STRATEGIC PRIORITY #1: The College of Science will be a global leader in fundamental and transdisciplinary scientific research, discovery, scholarship, and education.**<br><br>• GOAL 1: Expand the depth and breadth of science scholarship, focusing on research excellence, and increase the impact of research and discovery in the College of Science.<br>• GOAL 2: Enhance basic research and disciplinary areas of distinction, while simultaneously building transdisciplinary research capabilities and investing in high-impact strategic research opportunities.<br>• GOAL 3: Provide cutting-edge, meaningful, transformative, and high-quality educational experiences for all students, including ensuring that non-College of Science students learn to appreciate the importance of science and scientific inquiry. | 1. Increase the number of Fellows in professional societies:<br>   a. National Academies<br>   b. AAAS<br>   c. Fellows of each discipline's major professional society<br><br>2. Increase the number of large proposals funded by College Principal Investigators:<br>   a. $1M - $5M<br>   b. > $5M<br><br>3. Increase the number of graduate students on research assistantships (GRAs):<br>   a. Total number<br>   b. Percent increase each year | 1. Total number of Fellows in COS:<br>   a. TBA* by 2026.<br>   b. TBA* by 2026.<br>   c. TBA* by 2026.<br><br>2. Number of funded large proposals<br>   a. TBA* by 2026.<br>   b. TBA* by 2026.<br><br>3. a. Achieve TBA* GRA FTEs by 2026.<br>   b. Increase by TBA* % per year. |
| **STRATEGIC PRIORITY #2: The College of Science will continue to build a robust, durable, diverse, inclusive, and thriving scientific community focused on excellence.**<br><br>• GOAL 1: Enhance our ability to attract, hire, and retain the best faculty, staff, and students from around the world, with an emphasis on improving the diversity of the College of Science in all dimensions.<br>• GOAL 2: Increase the number of women, underrepresented, first generation, and historically disadvantaged students, to more closely align College of Science undergraduate student demographics with the Commonwealth's, and establish processes to support their success.<br>• GOAL 3: Promote a culture focused on excellence in all that we do – teaching & learning, research & discovery, and service & outreach – recognizing that a diverse and inclusive environment is the foundation upon which excellence in science is built. | 1. Increase the number of endowed faculty positions:<br>   a. Sesquicentennial Chairs<br>   b. Faculty Chairs<br>   c. Professorships<br>   d. Senior Faculty Fellowships<br>   e. Faculty Fellowships<br><br>2. Increase the average College graduate student stipend.<br><br>3. Meet or exceed PIBB student success, diversity and inclusion goals. | 1. Achieve at least 35 College of Science endowed faculty positions by 2027.<br><br>2. Increase annual stipends by $5K on average by 2023.<br><br>3. Meet PIBB goals by 2023. |

| STRATEGIC PRIORITY #3: The College of Science will excel in outreach, engagement, and economic development to promote healthy people, strong communities, and a sustainable planet. | 1. Increase non-traditional research partnerships with corporate partners and Government sponsors related to expansion in Roanoke and the Greater Washington, D.C. Metro area. | 1. Establish at least one long-term partnership worth at least $5M total by 2024. |
|---|---|---|
| • GOAL 1: Establish partnerships with alumni, industry, the public, and local and national policymakers in order to increase the impact of our research, improve the visibility of our faculty and students, and promote societal well-being.<br>• GOAL 2: Enhance the College's outreach and engagement activities to promote science and scientific literacy, increase awareness of Virginia Tech and the College of Science, and attract the best and brightest faculty, staff, and students to the College.<br>• GOAL 3: Support economic development in the Commonwealth, particularly related to the University's efforts in Roanoke and the Greater Washington, D.C., Metro Area with an emphasis on the College's strengths in basic science, applied science, data science, and decision science. | 2. Increase number of students enrolling in master's degrees per year.<br><br>3. Increase number of students participating in outreach and engagement activities, experiential learning. | 2. Achieve annual enrollment of TBA[*] by 2026.<br><br>3. Achieve annual participation of TBA[*] by 2026. |

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|---|---|---|
| **STRATEGIC PRIORITY #4: The College of Science will invest in the College's people and infrastructure to fully support our missions of teaching, research, and service.**<br><br>• GOAL 1: Support and encourage the professional development, career satisfaction, and work-life balance of College of Science faculty and staff so they may reach their full potential, maximize their quality of life, and make the College a destination for new talent.<br>• GOAL 2: Develop and expand the College's financial resources, including maximizing revenue returned to the College under the Partnership for an Incentive-Based Budget (PIBB), in order to support College operations via robust funding and other assets that are resilient to external influences.<br>• GOAL 3: Improve the quality and quantity of College facilities and infrastructure to best support faculty teaching and research productivity, including the establishment of affordable shared research facilities to promote research excellence and financial efficiency. | 1. Total dollars invested in high-impact strategic research opportunities.<br><br>2. Total philanthropic support raised for student scholarships and fellowships.<br><br>3. Total philanthropic funding for program and research support and facilities/equipment.<br><br>4. Total philanthropic funding raised for annual funds. | 1. $ TBA[*] K/year in high-impact strategic opportunities (e.g., Appendix E topics).<br><br>2. Achieve $25M by 2027.<br><br>3. Achieve $20M by 2027.<br><br>4. Achieve $10M by 2027. |

[*] Will be determined in summer 2020

## APPENDIX A: STRATEGIC PLANNING PROCESS

Led by Dean Sally Morton, the College of Science's strategic planning process was designed to ensure alignment with Advancing Beyond Boundaries: the (University) Strategic Plan. Dean Morton selected Drs. Ron Fricker and Steve Holbrook as College of Science Strategic Planning Co-Chairs. The College partnered with the Virginia Tech Office for Strategic Affairs: Ms. Erin McCann, Virginia Tech's Director for Strategic Planning, co-led the effort with Drs. Holbrook and Fricker.

[Dean Morton kicked off the College of Science strategic planning process with a town hall](#) in May 2019. Faculty and staff were invited to share feedback on revising the vision, mission, and values statements of the College of Science, as well as strengths, opportunities, and challenges through surveys and in-person meetings. The College of Science 2019 Spring Roundtable included a presentation on the University Strategic Plan and workshop sessions with Roundtable members to inform the College of Science strategic planning process and potential areas of focus.

This feedback was then utilized to inform working group activities throughout the summer of 2019. Sessions included the College of Science Staff Retreat in June, which generated thoughts and input about how the College of Science could contribute to the four strategic priorities in the University Strategic Plan; and the College of Science Chairs Retreat which included brainstorming on transdisciplinary research opportunities focused on solving grand challenges.

During fall 2019, the College of Science reviewed the College's Diversity Plan (developed 2017-2018 consistent with InclusiveVT) to ensure alignment with the College of Science strategic plan. The College of Science strategic plan has been developed with the existing College of Science Diversity Implementation Plan in mind. Initiated more than two years ago, the Diversity Implementation Plan includes many College-wide diversity related goals that remain relevant and are an integral part of the strategic goals around the core value of Diversity and Inclusion.

Throughout September and October 2019, faculty, staff, and students engaged in brainstorming sessions to inform the College of Science strategic plan and potential areas of focus. In addition, the College of Science invited faculty to submit short white papers proposing interdisciplinary research areas that addressed grand challenges, were poised for discovery, and could attract substantial external funding (see Appendices E and F).

During February and March 2020, faculty, staff, students, and Roundtable members were invited to share feedback on initial drafts of the College of Science strategic plan. The feedback was incorporated into the final version, which was presented to the College in May 2020.

## APPENDIX B:  THE COLLEGE OF SCIENCE: WHO WE ARE

Researchers in the College of Science produce discoveries that inspire wonder, generate new understanding of fundamental scientific processes, and solve problems of deep importance to human societies. From understanding the nature of black holes to unraveling the inner mechanisms of molecular biology, the departments in the College of Science span the great breadth of scientific inquiry.

Uniting this diversity across departments and disciplines is our vision of being "fueled by data, focused on discovery, and directed at decisions." Our work is grounded in collaboration across disciplines, aimed at transformative discoveries to understand complex systems, and convergent in developing and applying shared techniques in data analytics, which reveal insights captured from data.

The College of Science attracts, develops, supports, and celebrates leaders in their fields, across a range of interconnected, collaborating departments that have their own unique histories and strengths:

### Department of Biological Sciences

The Department of Biological Sciences strives to be an internationally recognized leader in the acquisition and dissemination of fundamental knowledge of the living world, knowledge that will improve the health of the planet, including humans. The department seeks a more complete understanding of life processes by integrating knowledge across a broad range of scales—from single molecules to whole ecosystems; approaches —from theoretical methods to field studies and bench work; and experimental systems—from viruses, bacteria and yeast, to birds, reptiles and humans. We are proud to share that many of our students go on to successful careers as academicians, physicians, environmental and health industry professionals, entrepreneurs, lawyers, teachers, and public servants. Areas of distinction in the department include: ecology, evolution and organismal biology; molecular and cell biology; and microbiology and immunology.

### Department of Chemistry

The Department of Chemistry pursues theoretical and laboratory research, from basic to applied, across many aspects of molecular science. We address human problems spanning new materials, energy storage and use, water purification, and drug discovery, as well as fundamental chemistry such as electronic structure theory, polymers, chemical kinetics, organic and inorganic synthesis, spectroscopy, electrochemistry, interfacial chemistry, catalysis, and more. Our faculty and graduates are leaders in academic research and education, chemical and pharmaceutical industries, government research and regulatory agencies, and medicine and other health professions. Areas of distinction include: polymers and macromolecular science, theoretical and computational chemistry, medicinal chemistry, and synthesis, reaction dynamics, measurement and mechanism.

### Department of Economics

The Department of Economics focuses on excellence in research, teaching, and outreach for addressing economic issues at the state, national and international levels. Economics focuses on understanding the fundamentals of human decision-making at the micro and macro level and how these relate to better policies and sustainable economic development and quality of life. While the department has always had strength in the core areas of economics, over the last few years the department has built strength in emerging areas like behavioral economics and data driven decision-making, backed by a core group of theorists and applied economists and experimental/neuroeconomists. The department trains students with a focus on analytical and communication skills and data driven decision-making to provide the skills necessary to excel in a rapidly evolving interconnected global economy. The department is strongly committed to diversity both in its pedagogical mission and in creating a diverse student and faculty body. The department is involved in several transdisciplinary initiatives like the new Behavioral and Decision Science undergraduate degree, the Data and Decisions minor, and the Politics, Philosophy, and Economics program.

### Department of Geosciences

The Department of Geosciences addresses all aspects of Earth and planetary sciences, striving for internationally recognized excellence in discovery, learning, and engagement. Our faculty, students, and staff address the great geoscientific challenges facing human societies: climate change and its impacts; food and water security; environmental (and linked human) health; sustainability of mineral and energy resources; and resilience to natural hazards. Our students are trained to take up careers in the energy industry, environmental and engineering geology, government research and regulatory agencies, and education. Areas of distinction in the department include: environmental geoscience, Earth materials, Earth structure, Earth history, planetary science, Earth resources, hazards and resilience, and quantitative geoscience, including "big data" analytics.

### Department of Mathematics

The Department of Mathematics aims for international leadership in research, education, and outreach in and across four core areas: Mathematical Analysis and Differential Equations; Scientific Computing, Numerical Analysis, and Data-driven Science; Algebraic Combinatorics, Geometry and Cryptology; and Mathematics Education. Important research topics within and across our core areas are the mathematics of Big Data, including machine learning, high-performance computing and efficient algorithms for very large data sets arising from scientific, economic, and social applications, and topological data analysis; cybersecurity, cryptography, and privacy/information security; quantum information science, quantifying and modeling uncertainty in systems of differential/difference equations with stochastic and uncertain components; the mathematics of nonlinear behavior, and important applications to the

modeling of pathogens and the spread of infectious diseases; and effective mathematics education at the college level.

Mathematics is crucial to the science, technology, and engineering research enterprise; mathematics is omnidisciplinary. New mathematics emerges from questions within mathematics and from problems outside of mathematics, and mathematicians are the researchers most likely to identify mathematical principles that clarify and advance research in other disciplines and transfer insights across disciplinary lines.

## Department of Physics

The Department of Physics is known for its research excellence in strategically chosen areas of national and international interest, as well as excellence in teaching. The department provides quality experiential learning opportunities to the vast majority of its undergraduate majors and has recently risen to the national top ten in numbers of bachelor's degrees produced. The department has research prominence and growing expertise in a number of areas, including: neutrino physics, a top priority of the high energy physics community for the next several decades; quantum condensed matter, including growing success with quantum information science; soft matter and biological physics, including the Center for Soft Matter and Biological Physics; string theory, including one of the largest string theory groups in the nation and leaders in connecting string theory to experimental observations; astrophysics, including several new major instruments coming online; fundamental symmetries and forces, including new major facilities planned (such as the Electron Ion Collider); and emerging areas such as the physics of living systems and multi-messenger astrophysics.

## Department of Psychology

The Department of Psychology is an internationally recognized department focused on the interplay of innovative, basic science research and translational/dissemination science. Psychology is a hub science, in that its research influences scientists in multiple disciplines and has become increasingly central to policy. Psychologists provide the theory and expertise critical for virtually all projects across disciplines that involve human behavior in any way. Faculty research in the department falls into four graduate areas of specialization: biological psychology, clinical science, developmental science, and industrial and organizational psychology. In addition, the department has overlapping research themes that bridge faculty and graduate student research areas across these four traditional areas, including cognitive health and wellbeing; diversity, health, and social disparities; human decision making; and risk, resilience, and stress.

## Department of Statistics

The Department of Statistics aims to be the preeminent applied statistics department in the United States and globally. The department's mission is to: develop future statisticians and data scientists at both the graduate and undergraduate levels; conduct fundamental research on

statistical methodology applied to the natural and social sciences, engineering, healthcare, government and industry; educate scientists, engineers, and students across the University on statistical theory, methods, computation, and applications; and to collaborate and support the broader scientific community in the generation of knowledge via the application of statistical methods. The department has several emerging areas of excellence, including: industrial statistics, Bayesian methods and modeling, computationally intensive statistical methods, machine learning, methods for high-dimensional data, data mining, biostatistics and health analytics, and uncertainty quantification, particularly related to leveraging large-scale computational models for scientific inference.

## Academy of Integrated Science

The Academy of Integrated Science brings together multiple areas of expertise to explore powerful new approaches to current complex scientific problems. The innovative Integrated Science Curriculum (ISC) offers a two-year, deeply interdisciplinary educational experience centered on student teams working in labs and lectures. The Academy houses six interdisciplinary programs in the College of Science, including relatively new degree programs in Computational Modeling and Data Analytics, Nanoscience, and Systems Biology. A fourth new degree program in Behavioral Decision Science is under development.

## School of Neuroscience

Neuroscience is a discipline that informs and is informed, by essentially every aspect of human endeavor. Neuroscientists seek to understand how we perceive the world we live in and interact with each other; how we form memories, make decisions and express ourselves. Neuroscientists translate knowledge about brain function to machine learning, neural networks, artificial intelligence, and robotic devices. The School of Neuroscience aims to be a world leader in delivering these insights to students through rigorous interdisciplinary studies and hands-on research. The principal areas of excellence in the School of Neuroscience are computational/systems neuroscience and clinical/experimental neuroscience. The School of Neuroscience is also at the forefront of research regarding adaptive and mal-adaptive changes that occur over an individual's lifespan, with hope to improve brain health from preconception to death. Diseases being studied include, among others: addiction, autism, Alzheimer's, depression, epilepsy, Parkinson's, Rett syndrome, cancer, head and spinal cord trauma, pain, and depression.

## APPENDIX C: STATE OF THE COLLEGE

The state of the College is strong. It is comprised of highly motivated faculty and staff who are focused on student growth and success, excellence in teaching, outreach and engagement, and advancing the research mission of the College. The College has a wide range of academic programs, both undergraduate and graduate, many of which are growing, along with a structure that promotes both disciplinary depth in fundamental science and transdisciplinary breadth that connects units across the College and expands research collaborations.

This assessment of the College was conducted in December 2019. As shown in Tables 1, 2, and 3, the College is growing in terms of personnel (faculty, staff, and students), research awards and expenditures, and philanthropic contributions.

**Table 1. College of Science Faculty and Students**

|  | FY15 | FY16 | FY17 | FY18 | FY19 |
|---|---|---|---|---|---|
| Number of Full-time Faculty | 357 | 377 | 397 | 413 | 449 |
| Number of Tenure-track Faculty | 214 | 228 | 239 | 240 | 244 |
| Number of Staff | 112 | 104 | 116 | 119 | 121 |
| Number of Undergraduate Majors | 3,439 | 3,588 | 4,053 | 4,292 | 4,597 |
| Number of Graduate Students | 614 | 614 | 596 | 581 | 581 |
| Student Credit Hours Taught | 244,288 | 240,724 | 255,167 | 255,063 | ~296,000 |

**Table 2. College of Science Research Expenditures and Grants**

|  | FY15 | FY16 | FY17 | FY18 | FY19 |
|---|---|---|---|---|---|
| Research Expenditures | $21.9M | $21.5M | $23.6M | $26.8M | $30.7M |
| No. of Research Awards | 183 | 191 | 234 | 234 | 261 |
| Total of Research Awards | $21.6M | $25.5M | $28.6M | $35.7M | $34.5M |

**Table 3. College of Science Philanthropy**

|  | FY15 | FY16 | FY17 | FY18 | FY19 |
|---|---|---|---|---|---|
| Alumni Participation | 6.8% | 7.1% | 8.8% | 10.2% | 11% |
| Annual Funds | $389,599 | $466,453 | $485,884 | $747,462 | $766,462 |
| Beyond Boundaries Scholarships | N/A | N/A | $9,000 | $188,400 | $140,500 |
| Donor Count | 899 | 987 | 1,001 | 1,486 | 1,763 |
| Total commitments | $3.1M | $3.4M | $11.5M | $7.9M | $4.5M |

The College of Science is a true cornerstone of the University in a pedagogical sense and it is a key component of the intellectual heart of the University in a research sense. It is responsible for one-quarter of all of the instruction hours at Virginia Tech (in academic year 2018-19, the College taught 255,063 hours out of 1,033,337 total hours) and faculty in the College teach more than 98% of the undergraduates at the University. The quality of the College's academic departments and curricular programs are reflected in their external recognition and awards. To mention just one measure, in the past five years four of our departments (Biological Sciences,

Chemistry, Geosciences, and Physics) have all won the Virginia Tech Exemplary Department Award; Chemistry has won the award three years out of the past five.

The College of Science also plays a central role in the intellectual vibrancy of Virginia Tech and in its aspirations to be a world class comprehensive University. We are the key to the continued future success of Virginia Tech, and the College of Science plays a particularly vital role in achieving the following goals in the University's Strategic Plan:

- "*Achieve Top 10 U.S. public land-grant (WSJ/THE U.S. College Rankings) by 2024.*"
- "*Achieve Top 13 U.S. land-grant (THE World University Rankings) by 2024.*"

Of course, rankings are, at best, proxy measures of educational and scholarship quality. However, the College's deep commitment to world class scholarship, fundamental research, pedagogical excellence, innovation, and outreach positions us as *the* College at the University with the ability to significantly "move the needle" on Virginia Tech's ranking.

For example, as shown in Table 4, the College of Science produces more citations per faculty member than any other College in the University and the College of Science is essentially tied for the average number of publications per tenure- track faculty member.

### Table 4. College of Science Publications and Citations
### Per Tenure-track Faculty Member by College/Area

| College | Articles/Faculty | Citations/Faculty |
|---|---|---|
| COS | 11.5 | 210 |
| COE | 11.6 | 195 |
| CNRE | 9.8 | 123 |
| CALS | 8.4 | 94 |
| PCOB | 4.5 | 79 |
| Social Science | 5.2 | 49 |
| Humanities | 1.3 | 2 |

*Source: Academic Analytics.* Groupings as defined in AA;
Articles from 2015-18 and citations from 2014-2018.

In a similar vein, programs within the College of Science accounted for the second highest percentage of votes for either the "Top 15 best research universities in the world" or the "Top 15 best teaching universities in the world" in the Times Higher Education (THE) 2019 data. Furthermore, a review of the THE reputation rankings methodology suggests College of Science faculty are "punching above their weight class" in terms of those factors contributing to THE rankings – e.g. citation impact, international collaborations, and contributions to top 10% and top 25% journals.

Finally, at the expense of possibly overemphasizing the importance of financial measures, 6% of the Times Higher Education ranking weight is on research expenditures. As shown in Table 5, the College of Science's expenditures are the second highest among all Virginia Tech Colleges; we've increased them by nearly 43% over the past four years, by far the highest percent increase over any College with more than $5M in research expenditures.

**Table 5. College Research Expenditures**
Ordered by Percent Change

| College | FY16 | FY17 | FY18 | FY19 | % Change |
|---------|------|------|------|------|----------|
| CLAHS | $3.1M | $5.2M | $4.7M | $4.8M | 54.8% |
| COS | $21.5M | $23.6M | $26.8M | $30.7M | 42.8% |
| PCOB | $2.6M | $3.4M | $3.1M | $3.0M | 15.4% |
| COE | $88.8M | $84.1M | $91.4M | $100.8M | 13.5% |
| CVM | $6.2M | $6.3M | $6.7M | $6.9M | 11.3% |
| CAUS | $1.2M | $1.2M | $1.8M | $1.3M | 8.3% |
| CNRE | $14.8M | $15.0M | $14.5M | $14.1M | -4.7% |
| CALS | $34.9M | $31.3M | $29.4M | $29.7M | -14.9% |

*Source: UDC-RM. Teaching and Public Service Expenditures Removed, as Identified in Microstrategy.*

Of course, all of these are at best imperfect measures of the College's highly motivated and incredibly talented faculty and staff who are focused on research and teaching excellence, student growth and success, and outreach and engagement. The quality of College of Science faculty is best reflected in their external recognition. For example, since 2015:

- Fourteen College of Science faculty members have won National Science Foundation (NSF) CAREER awards, the NSF's "most prestigious award in support of early-career faculty who have the potential to serve as academic role models in research and education and to lead advances in the mission of their department or organization."
- Four College of Science faculty members have received the State Council of Higher Education for Virginia's Outstanding Faculty Awards, which are "the Commonwealth's highest honor for faculty at Virginia's public and private colleges and universities."
- Two College of Science faculty have been selected as Virginia Outstanding Scientists, which "honors those scientists who, through their research and commitment to science, have made a recent contribution to basic scientific research that extends the boundaries of any field of science."

Staff are the foundation of the College of Science upon which both faculty and student success are built. Our staff provide services that include academic advising, IT support, coordination and preparation of teaching laboratories, conducting experiments in research laboratories, undergraduate and graduate program coordination, production of laboratory instruments, management and direction of a museum, and fiscal, human resources, administrative, and general office support. The College highly values and respects our staff whose support and contributions enable the College to explore, teach, advance, and apply science.

Diversity is an ethical, pragmatic, and essential component of the College and science in general, where the inclusion of different disciplines, ideas, and insights is fundamental for the growth of science. The College of Science is committed to helping create and sustain a faculty, staff, student body, and community, which is welcoming of the vast array of cultures and perspectives through which we strengthen ourselves, our work, and the world around us.

As a result of collaboration among College leadership, faculty, and staff, and an environment of shared governance, the College of Science has a generally positive climate as measured by the COACHE survey. The College has a core of very dedicated and engaged alumni, including the College of Science Roundtable, who seek to advance the College.

While the state of the College is strong, it faces a number of challenges, including a lack of space, the quality of some existing space, and the costs of start-up packages that are becoming unaffordable. Because the University is in a period of significant growth, both in terms of the size of the undergraduate population and the number of new programs being launched, faculty and staff are stretched, available space is very tight, and budgets are being challenged. While the College has been a beneficiary of increased funding under the new budget model (the Partnership for an Incentive-Based Budget or PIBB) thus far, the PIBB has not yet been fully implemented and even with the full PIBB funding, the College will require additional resources to fully meet its mission.

That said, the College of Science's vitality is reflected in its world-class faculty; motivated, engaged, and innovative students; talented and committed staff; inclusive environment; engaged alumni; and a unique organization that promotes synergy across scholarly fields. The College is poised for significant contribution to a number of Virginia Tech initiatives, including the Innovation Campus and other Greater Washington, D.C., Metro Area initiatives, the Health Sciences and Technology Campus in Roanoke, and Virginia state efforts such as the Commonwealth Cyber Initiative. Based on our foundational strengths in undergraduate and graduate education, disciplinary excellence, and novel interdisciplinary programs, over the next five years the College of Science is well-positioned to take its place as a leader among the world's Colleges of Science.

## APPENDIX D: SWOT ANALYSIS

This appendix contains a review of the College's strengths, weaknesses, opportunities, and threats (SWOT) informed by a faculty and staff survey and focus groups conducted with key stakeholders, including students, alumni, faculty, staff, and the College of Science Roundtable. Key SWOT themes are identified below; strengths and weaknesses are internal to the College, and Opportunities and Threats are external and divided into two groups: external to Virginia Tech, and internal to Virginia Tech but external to the College of Science. While this list is not exhaustive, it provides a useful context for the development of the strategic planning framework. This SWOT analysis was conducted in August 2019, prior to the COVID-19 pandemic. This event has placed even more pressure on several of the identified threats, most notably those related to financial resources.

### Strengths

- Dedicated Faculty and Staff – The College of Science is comprised of highly motivated faculty and staff who are focused on student growth and success, excellence in teaching, outreach and engagement, and advancing the research mission of the College.
- Positive Growth Trends – The College of Science is growing in terms of personnel (faculty and students), programs, research awards and expenditures, and philanthropic contributions, and is well-positioned for additional budget increases under the PIBB.
- Quality Academic Programs – The College of Science has a wide range of undergraduate and graduate academic programs, many of which are growing, along with a structure that promotes both disciplinary depth in fundamental science and transdisciplinary breadth that connects departments and expands research collaborations.
- Positive College Climate – As a result of collaboration among College leadership, faculty, and staff, and an environment of shared governance, the College of Science has a generally positive climate as measured by the COACHE survey.
- Dedicated and Engaged Alumni – The College of Science has a core of very dedicated and engaged alumni, including the College of Science Roundtable, who seek to advance the College.

### Weaknesses

- Resource Limitations – The College has been historically underfunded, resulting in departments that are generally smaller than peer departments at other universities and that are stretched for space (both offices and laboratories), staff support, and other resources.
- Ability to Compete for Faculty – Due to university resource constraints, including a lack of shared facilities at the university, insufficient cost sharing of faculty start-ups in lab-based departments, and the Virginia Tech faculty salary structure, the College of Science has difficulty competing against peer institutions for faculty. Faculty from underrepresented and historically disadvantaged groups are often a particular recruiting

challenge as other institutions are able to offer salaries and start-up packages against which the College is unable to compete.

- Graduate Research Assistantship (GRA) Opportunities – For a variety of reasons, including the requirement to pay full tuition for graduate students and comparatively low external funding, the College of Science lags its peers in the number of graduate research assistantship opportunities available to graduate students and that limits the total number of graduate students, and thus research productivity, in the College.
- Faculty and Student Diversity – Despite a significant focus on improving diversity by the College and its departments, it is difficult to attract and retain underrepresented faculty because University programs such as the Future Faculty Development and Target of Talent programs are not well aligned and the competitive landscape of underrepresented faculty poses a challenge.
- Philanthropy – Historically, the University has not established a culture of philanthropic giving and thus lags in the amount of philanthropic resources compared to peer universities; this is reflected in College philanthropy as well.

## Opportunities

**External to Virginia Tech:**
- Commonwealth's Emphasis on Economic Development – The College of Science is well-positioned to establish and expand educational programs to support economic growth in the Commonwealth, including under the Higher Education Package and the Commonwealth Cyber Initiative, as well as in the Greater Washington, D.C., Metro Area and Roanoke and as part of the Rural Virginia Initiative.
- Societal Trends – There is a good match between College of Science curricular offerings and societal interests, as a perceived increased value of higher education in the sciences and engineering is resulting in a growing demand for graduates with quantitative and programming skills.
- Data Science – There is a strong demand and employment opportunities for graduates who are well-versed in data science methods; the College has broad and deep expertise in these methods and a variety of curricula focused in this area.
- Interdisciplinarity and Interdisciplinary Science – The future of science is centered on the synergistic integration of and coordination across traditional science disciplines to address transdisciplinary problems and the College of Science is well positioned to take advantage of it via the Academy of Integrated Science and its interdisciplinary degree programs.

**External to the College:**
- Virginia Tech Emphasis on Rankings – The Virginia Tech Strategic Plan's emphasis on increasing rankings is an opportunity, where the College's deep commitment to world class scholarship and fundamental research positions the College of Science as *the* College with the ability to significantly "move the needle" on Virginia Tech's rankings.
- Virginia Tech's Strategic Initiatives – With its expertise in fundamental science, transdisciplinary abilities, and data science methods, curricula, and programs, the

College of Science is well-positioned to support the new Innovation Campus in the Greater Washington, D.C., Metro Area and the Health Sciences and Technology Campus in Roanoke.

- Partnership for an Incentive-Based Budget – Thus far, the College of Science has benefitted from PIBB implementation, partially addressing the Resource Limitation previously mentioned under Weaknesses above. Assuming the PIBB will be fully implemented, it should provide additional financial resources to the College.

## Threats

**External to Virginia Tech:**

- Changing Dynamics in Higher Education – While Virginia Tech experienced significant over-enrollment this year, future demographic shifts point to the possibility of declining enrollments.[2,3]   Such declines, if they impact Virginia Tech, could result in reduced revenue to both the University and the College.
- State/Federal Funding Reductions – With the change in the composition of the state legislature, there is the potential for changes in state support and the potential need to generate new streams of revenue from non-traditional sources, all while keeping the cost of attendance affordable.
- Higher Education Package Restrictions – It is unclear at this time whether the Commonwealth will eventually broaden its focus from Computer Science curricula for the Higher Education Package to include relevant College of Science curricula.
- Uncertain Economy – There is always the possibility of an upcoming recession sufficient to impact the state budget, and thus revenue, to the University.

**External to the College:**

- Aging Facilities – The University has substantial deferred maintenance and older buildings that require funding to maintain and restore, particularly Derring, Hahn, McBryde, and Robeson Halls in the College of Science, and these facilities hinder faculty recruiting, retention, and the conduct of research.
- Rapid University Growth – The University is in a period of significant growth, both in terms of the size of the undergraduate population, and the number of new programs being launched. These changes are stretching faculty and staff, exceeding space available, and challenging budgets.
- Lack of Financial Resources – While the College has been a beneficiary of increased funding under the PIBB thus far, and is scheduled for further increases, additional resources are required to fully fund a number of student-focused initiatives such as supporting faculty with advising staff for College of Science majors. However, the PIBB

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[2] Piper, J., "Enrollment Dropped 1.3% This Fall From a Year Ago. But Not Every State Tells the Same Story," *Chronicle of Higher Education,* (www.chronicle.com/article/Enrollment-Dropped-13-This/247719), Dec. 16, 2019.
[3] Nadworney, N., "Fewer Students Are Going To College. Here's Why That Matters," *National Public Radio*, www.npr.org/2019/12/16/787909495/fewer-students-are-going-to-college-heres-why-that-matters, Dec. 16, 2019.

has not yet been fully implemented and, thus far, College of Science program fees have not been approved.

- Faculty Start-Ups – The University start-up model pushes most of the cost of start-up for lab-based faculty onto Colleges and departments. As the cost of these packages increases, in order to effectively compete for faculty, these start-up packages are becoming unaffordable.

## APPENDIX E:  HIGH-IMPACT RESEARCH STRATEGIC OPPORTUNITIES

In the Fall of 2019, the College of Science invited faculty to submit short white papers proposing interdisciplinary research areas that addressed grand challenges, were poised for discovery, and could attract substantial external funding. The titles of the submitted white papers are contained in Appendix F. These were subsequently reviewed by a faculty committee, which requested further development of specific opportunities. In some cases, similar ideas were merged into an overarching strategic opportunity.

The following opportunities are aligned with the University Strategic Plan priorities, with particular emphases on advancing regional, national, and global impact by increasing excellence in research, discovery, and creativity; and elevating the Ut Prosim (That I May Serve) Difference by addressing critical societal issues impacting humanity and equity.

1. Data Science. Data science is impacting all branches of science. The need for methodological developments and the education of all scientists in data science has never been greater. The Virginia Tech College of Science sees this demand via requests from our faculty for professional development in data science, and for data science education for our graduate students and postdoctoral fellows to enhance both our educational and research missions. Roughly half of the white papers submitted by our faculty regarding our College's strategic research directions concerned some aspect of data science (see Appendix F). Data science is a science in its own right and it is now an essential component of every scientific discipline. Thus, the College requires a focused effort that includes both the *science of* data science, as well as the use of data science *in science*.

2. Quantum Information Science. Quantum information science and technology (QIST) has the potential to yield transformative applications that would impact the economy, society, and national security. Emerging and future quantum technologies include quantum computing, quantum simulation, secure quantum communications, and quantum-enhanced sensing, which will yield transformative applications that impact the economy, society, and national security. In December 2018, the United States Congress demonstrated its own commitment by passing the National Quantum Initiative Act, which provides $1.2 billion over the next five years (with additional investment in the following five years) to accelerate the development of QIST applications. We are now in a critical moment in which universities and national laboratories are positioning themselves to benefit the most from this unfolding paradigm shift.

3. Coastal@VT: A Community of Action. Over half of the world's population lives in the coastal zone and is, therefore, exposed to impacts of terrestrial and marine processes. Climate change impacts, such as sea-level rise, threaten important nodes of the global economy, critical infrastructure for civil and national security, and fragile (marine and terrestrial) ecosystems. Quantifying and predicting – both areas of excellence in the College of Science – the consequences of resource limitation, opportunity, and vulnerability within the coastal-

zone network will generate knowledge crucial for the design of sustainable solutions for the benefit of all – which is Coastal@VT's goal. Coastal@VT fosters interdisciplinary coastal-zone capacity building within Virginia Tech, and finds, forms, and nurtures the connections between interdisciplinary research at Virginia Tech and diverse stakeholder groups.

4. **Advancing Predictive Modeling for the Biosciences: From Cells to Ecosystems.** At every scale of biology - from the interaction of molecules to the interaction of species - computational modeling has become an essential tool to elucidate emergent behavior, make accurate predictions, highlight fundamental gaps in understanding, and design optimal experiments. Advancing predictive modeling to support discoveries in the biosciences is the key focus of this initiative and will help address both societal and fundamental science problems. Challenges that need to be overcome to advance predictive modeling include: breaking down barriers between disciplines, diversifying the current modeling approaches, bridging predictions across different scales of biology (molecular, cellular, organismal, ecological), incorporating advances in the computer sciences, and training scientists with multidisciplinary knowledge, who can advance this field.

5. **Materials in Medicine Research Initiative: At the Nexus of Science, Engineering, and the Clinic.** Advances in medicine demand breakthroughs in materials design and performance, leading to a programmable toolbox of precise, multifunctional materials. Nanoscale drug delivery vehicles, drug-eluting stents, artificial organs, 3D printed prosthetics, and beyond require a transdisciplinary approach to discovery where scientists in chemistry, biology, physics, geoscience, computer science, and statistics must team together with engineers and physicians to innovate solutions. Scientific challenges include the need to push the limits of computation and experimentation to be able to probe complex biological environments and synergistically integrate computation with material syntheses to make the computed structures a reality.

6. **A Vision for Ecological Forecasting at Virginia Tech:  A Transdisciplinary Initiative.** In the 21st century, our ability to understand nature, manage natural resources, and conserve Earth's life support systems will require a capacity to anticipate environmental change at a scale and speed far beyond what we can do now. Widespread environmental change is the defining challenge of our time, with impacts already being felt across society at scales from national policy (e.g., global climate change, biodiversity loss, resource overexploitation) to communities and individuals (e.g., wildfire, tick-borne disease, harmful algal blooms). We are not facing a 'new normal' but continuous, accelerating change. In the face of this change, our nation can no longer rely on historical norms for environmental decision-making, as demonstrated by recent unprecedented droughts, floods, fires, coral bleaching, and extinction events. Informed decision making requires the development of ecological forecasts: continually updated, actionable predictions with uncertainties of the state of ecosystems and their services.

7. **Materials for Safe and High-Density Energy Storage and Efficient Molecular Separations.** This research initiative will build on core strengths within the College and across campus to invent new finely controlled materials for fundamental leaps in energy storage and efficient molecular separation/sorption technologies. Advancements in renewable energy sources

and industrial applications of molecular separation processes and devices depend on the development of new materials and new understanding of materials uses. These applications all rely on common scientific concepts to expand beyond current boundaries and bring new technologies into common use.

8. **Virginia Tech Alliance for Neurodevelopmental Disabilities Research.** According to the Centers for Disease Control and Prevention, one in every six children in the United States has a neurodevelopmental disorder. These disorders may manifest as motor or sensory dysfunction, impaired learning, delayed or abnormal language, or non-verbal communication, development, or impaired neuropsychiatric function. The annual cost of neurodevelopmental disorders is exceptionally high; for example, the cost of autism alone in the US exceeds $200 billion dollars/year. This effort would provide a greater understanding of healthy and aberrant brain development using hypothesis-driven discovery in pre-clinical studies and human brain development for the advancement and effective implementation of early interventions strategies, and targeted therapeutics for the most common neurodevelopmental disorders.

9. **Astronomy and Planetary Science.** Astronomy and Planetary Science (APS) is an emerging grass-roots collaboration between Physics, Geosciences, and the Center for Space Sciences and Engineering Research (Space@VT) in the College of Engineering. APS addresses fundamental science questions and issues related to how the universe, our solar system, and exoplanetary systems formed and evolved; identifying and understanding the physical and chemical processes that affect planetary bodies; and whether there are potentially habitable environments in our solar system and beyond.

## APPENDIX F: LIST OF WHITE PAPERS

The following White Papers were submitted by College of Science faculty in response to a request by the dean in support of this strategic planning effort. These were reviewed by a faculty committee which requested further development of specific opportunities. In some cases, similar ideas were merged into an overarching strategic opportunity (see Appendix E).

1. Quantum Information Science
2. Coastal@VT: A Community of Action Test
3. A Vision for Ecological Forecasting at Virginia Tech: A Transdisciplinary Initiative
4. Advancing Predictive Modeling to Elucidate the Design Principles of Cells and Tissues
5. Quantitative Infectious Disease
6. New Strategies to Combat Antibiotic-Resistant Bacteria
7. Biomaterials at the Intersection of Computation and Experiment
8. Center for Immune Systems Engineering and Therapeutics
9. Materials for Safe and High-Density Energy Storage and Efficient Molecular Separations
10. Materials in Medicine Research Initiative
11. Integrating Deep Learning and Model Reduction: A Unified Framework for Data-driven Decision Making
12. Science-guided Machine Learning
13. Neurodevelopmental Disorders
14. Characterizing Earth's Subsurface through Machine Learning and Artificial Intelligence
15. Data-Driven Evaluation of Automated Driving System Safety
16. Reactor Neutrino Detector Technology for Non-proliferation and Industrial Applications
17. Advanced Materials for Advanced Packaging: A Pathway to Prominence
18. Artificial Intelligence for Imaging
19. Building a Robust Modeling Framework for Relating Environmental and Biological Predictability Across Spatiotemporal Scales
20. Virginia Tech Center for Brain Development in Health and Disease
21. Developing Novel "Big-data" Strategies to Identify the Neural Network Signature of Neuropsychiatric and Neurodegenerative Disorders
22. Forecasting with Context-driven Machine Learning Objective Functions
23. Sensitivity Analysis of High-Profile Large-Scale Statistical Simulation Models
24. Low-Energy-Threshold Superconducting Particle Sensors for Dark Matter and Neutrino Detection
25. Designing a Mechanism for Managing Climate Change
26. Astronomy and Planetary Science: A Proposed Interdisciplinary Strategic Initiative in the College of Science at Virginia Tech
27. Behavioral Foundations of Decision-Making in Health