Virginia Tech Degree Proposal

Neuroscience Bachelor of Science Degree
CIP: 26.1501

Type of degree action (circle one): (New) Spinoff Revision Discontinuance

Program Background

Virginia Tech seeks approval for a new Bachelor of Science (B.S.) degree in Neuroscience, with a planned implementation date of Fall 2015. Given the inherently interdisciplinary nature of neuroscience, this degree program will be situated within our newly formed Academy of Integrated Science, within the College of Science.

There is a growing demand in the US for better science, technology, engineering, mathematics, and health (STEM-H) education and programs. In fact, the US is rapidly falling behind international competitors in producing enough STEM-H graduates to meet rising demand.[1] The federal government realizes that targeting younger and younger students with specialized STEM-H training will be key in reversing this trend and continuously calls for solutions to this STEM-H pipeline crisis – often targeting programs as early as kindergarten. It has now become the mission of educators in the United States to improve STEM-H education in order to retain our standing as thought leaders to the world.

Neuroscience represents a unique academic field in that it requires students to understand and utilize a set of diverse knowledge from multiple disciplines. At Virginia Tech, neuroscience students will be exposed to a wide range of disciplines within the College of Science (including Biology, Chemistry, Economics, Mathematics, Physics, Psychology, and Statistics). Because of the interdisciplinary nature of the degree, neuroscience graduates will excel in integrating molecular, structural, physiological, cognitive, and behavioral aspects of the central and peripheral nervous systems.

Virginia Tech's B.S. degree program in Neuroscience will prepare students as future professionals in the 21st century. These students will not only be integral in maintaining and improving the health and well-being of the world's citizens, they are living in an era when – for the first time – neuroscience research decisions (and implementation) will be impacting society and the world. Topics like neurostimulation (the use of non-invasive stimulators to enhance brain function), neuroeconomics (the use of consumer behavioral data to drive business) and neurointegration (the use of brain machine interfaces) will soon become commonplace. Our students need to understand the impact of neuroscience in order to navigate these societal realities and become leaders in whichever field they decide to pursue after their undergraduate degree.

Through the proposed curriculum and research training, students will become conversant with the theories and methods of molecular, biochemical, cellular and systems neuroscience. They will gain an understanding of anatomical structures, physiological functioning, processing of information, adaptive and maladaptive cognitions/emotions/behaviors, disorders of the nervous system, and clinical/biomedical function of the nervous system. Neuroscience students will have depth and

[1] US Congress Joint Economic Committee, 2012

diversity in their "core" education and training by spanning multiple sciences. The graduates will not only have extensive and diverse "book knowledge", but will be exposed to, and trained in, a wide variety of research methods and laboratory techniques. As a result, the neuroscience degree curriculum will ensure that graduates are competitive for a range of employment markets in biomedicine, biomedical engineering, government service, (e.g., National Institutes of Health, Centers for Disease Control), marketing, sales, and ready for graduate degree programs (e.g., MBA, MA/MS) as well as professional (e.g., JD, MD, PhD) degree programs that either directly or indirectly pertain to neuroscience.

The importance of neuroscience

- More than 1,000 disorders of the brain and nervous system result in more hospitalizations and lost productivity than any other disease group, including heart disease and cancer.
- In 2007, the World Health Organization estimated that neurological disorders affect up to one billion people worldwide. In fact, neurological diseases make up 11 percent of the world's disease burden, not including mental health and addiction disorders.
- The cost of these diseases is high across the globe. For example, the European Brain Council estimated in 2010 that neurological diseases in Europe alone cost one trillion dollars a year.
- Data from 2005 indicate that neurological illnesses affect more than 50 million Americans annually and cost more than $500 billion to treat. In addition, mental disorders strike 44 million American adults a year at a cost of $148 billion.
- Advances in research could reduce these costs. Discovering how to delay the onset of Alzheimer's disease by five years could save $50 billion in annual health care costs in the United States alone.

There is strong demand for a neuroscience degree at Virginia Tech as there is widespread interest in the nervous system's structure and function among students and faculty spanning diverse departments within- and outside-of the College of Science. Given that this will be one of only a few truly interdisciplinary undergraduate degrees in science and mathematics in the Commonwealth, the degree will provide a unique and highly desired platform for study that will attract a diverse body of students from Virginia. The degree program will provide opportunities for in-state and out-of-state students to benefit directly from the rapid and exciting growth in neuroscience occurring at Virginia Tech. Students will take classes with scientists from a variety of backgrounds and disciplines, and will learn cutting edge neuroscience theory, research methods, and practical applications. By engaging in research and practical experience as part of the proposed degree, students also will be able to capitalize on the growth in neuroscience research within the college and at the Virginia Tech Carilion Research Institute. The time is right to launch this new interdisciplinary degree program that will reduce the likelihood of students in Virginia leaving the state to get this training, and will increase the likelihood that graduates of the program will remain in the state as they launch their careers.

Experimental/pilot Neuroscience courses began in Fall 2012 and will continue through 2015. The new courses for the degree began the formal approval process through VT internal governance in Fall 2013. If, as proposed above, the new degree program is initiated in Fall 2015, the first degrees are expected to be conferred in Spring 2016. Instruction will take place on the Virginia Tech campus in Blacksburg, VA. All courses will be traditional 'on campus' lecture, laboratory, seminar and research experience/independent study courses; no online/distance learning courses are included in the proposal.

Curriculum summary

The B.S. in Neuroscience degree comprises 120 credits, distributed among the following categories of courses: 1) Curriculum for a Liberal Education or CLE (general education) (38 credits); 2) Entry-Level College of Science Courses beyond CLE (20 or 3 credits if going through the ISC path); 3) Neuroscience Core Curriculum (24 credits); 4) Additional Requirements for the Major including Neuroscience Restricted Electives (12 credits); and 5) Free Electives (26 or 25 credits if going through the ISC path; totaling to 120 credits). The curriculum for the B.S. in Neuroscience is conceptually structured around two major components that provide breadth and depth: 1) an interdisciplinary foundation in sciences, mathematics and statistics (breadth); and 2) specialized introductory, intermediate and advanced courses in neuroscience with research/practical experience (depth).

The curriculum for this interdisciplinary neuroscience degree has its foundation in the natural, life, and behavioral sciences (e.g., biology, chemistry, physics, psychology), mathematics, and statistics. For depth, the neuroscience curriculum includes the Core Curriculum sequence (24 credits), along with Restricted Electives courses (12 credits). The Core consists of 10 courses, beginning with a first-year orientation seminar followed by a two-semester course sequence "Introduction to Neuroscience" and a two-semester lab sequence that will provide an interdisciplinary overview of cutting edge neuroscience and its applications. Students will then complete two intermediate 3000-level neuroscience courses (Cellular and Molecular Neuroscience and Cognitive Neuroscience). These will be followed, typically in the junior or senior year, by three 4000-level courses (Clinical Neuroscience, Neuroscience Senior Seminar, and Neuroscience Research/Practical Experience). The research/practical experience course will involve supervised research/practical experience work that will require students to leave the classroom and study as an intern by doing independent scholarship and/or practice with a mentoring faculty member. All projects will require library/literature research and writing, but the specific structure of the experience will be individualized to the student—this could take the form of an individual or small-team research study, or working in a medical/clinic setting, as just two examples. Students also will complete at least four restricted elective courses from a menu of options, to round out their neuroscience education by connecting their core course knowledge to closely related science and statistic courses of their choosing. Finally, students will select 26 or 25 credits (if going through the ISC path) of courses of their choice.

CLE: Curriculum for a Liberal Education (38 credits)
Area 1: Writing and Discourse (6 credit)
Area 2: Ideas, Cultural Traditions, and Values (6 credits)
Area 3: Society and Human Behavior (PSYC 2004, Introduction to Psychology, and one other 3-credit course; 6 credits)
Area 4: Scientific Reasoning and Discovery (BIOL 1105-1106, 6 credits lecture; plus BIOL 1115-1116, 2 credits lab; 8 credits total. Students can substitute BIOL 1005-1006 and BIOL 1015-1016 but only if hours were transferred upon admission or were taken here in a different major)
Area 5: Quantitative and Symbolic Reasoning (MATH 1205-1206, Calculus, 6 credits)
Area 6: Creativity and Aesthetic Experience (3 credits)
Area 7: Critical Issues in a Global Context (3 credits)

Entry-Level Science and Statistics Courses beyond CLE (20 credits or 3 credits if taking ISC—see NOTE below)

Complete 8 credit hours in Chemistry. Students must take CHEM 1035-1036 (6 credits lecture) and CHEM 1045-1046 (2 credits lab) for 8 credit hours total. Students can substitute CHEM 1015-1016 and CHEM 1025-1026 but only if hours were transferred upon admission or were taken here in a different major.

Complete 6 credit hours in Physics: Students must take PHYS 2205-2206 (6 credits).

All students complete 6 credit hours in Statistics: Students must take STAT 3615-3616 (6 credits). Note that for students who wish to specialize in statistics for neuroscience beyond this 6-credit requirement, you can also take STAT 3424 as a restricted elective (see below). Students in the ISC program must take STAT 3616.

Core Neuroscience Curriculum (24 credits)

The core curriculum will include the first year experience course and a two-semester Introduction to Neuroscience course along with the two-semester Neuroscience lab. Students will also complete five other core courses (2 at the 3000-level, 3 at the 4000-level) that will span cells to behavior and be organized around a variety of the major domains of neuroscience, and includes a course involving a supervised research or practical experience.

(*indicates new course)

*NEUR 1004 Neuroscience Orientation Seminar (1 cr)
*NEUR 2025 Introduction to Neuroscience (3 cr)
*NEUR 2026 Introduction to Neuroscience (3 cr)
*NEUR 2035 Neuroscience Lab (1 cr)
*NEUR 2036 Neuroscience Lab (1 cr)
*NEUR 3044 Cellular and Molecular Neuroscience (3 cr)
*NEUR 3084 Cognitive Neuroscience (3 cr)
*NEUR 4034 Clinical Neuroscience (3 cr)
*NEUR 4044 Neuroscience Senior Seminar (3 cr)
*NEUR 4054 Neuroscience Research or Practical Experience (3 cr)[+]

[+] The research or practical experience course is an important component of the proposed curriculum for the neuroscience degree. It is a research or practical experience project under the direct supervision of a neuroscience or affiliated faculty member, culminating in the format of a research poster presentation suitable for submission to a conference. The presentation will be read and reviewed by two faculty members who will submit "reviews." Although there is no requirement that the project/poster actually be submitted for presentation at a conference, we expect that the best ones will be. Because neuroscience research is done in teams, these research projects/experiences typically will report findings from a multi-investigator group, and the undergraduate student need not be the first author. The major advisor will document the contribution of the student to the research being described. The student should be considered the "corresponding author," in the sense that the poster must be written by the student alone. This

individualized research experience will provide the best exposure to cutting-edge neuroscience research and give each student an excellent preparation for employment or further study at the graduate level.

Additional Requirements for the Major (12 credits)

Restricted Electives (12 credits; 6 credits must be at the 4000-level)

The 12 credits of restricted electives are provided for the student to tailor his/her neuroscience degree through connections to other particular aspects of science and statistics. The restricted electives listed here are all courses currently offered by departments at Virginia Tech. At the request of a student, the director of the neuroscience undergraduate degree program may approve other courses as in-major restricted electives on an *ad hoc* basis.

ALS	2304	Comparative Animal Physiology and Anatomy (4 cr)
ALS/BIOL	4554	Neurochemical Regulation (3 cr)
BIOL	2104	Cell and Molecular Biology (3 cr)
BIOL	3404	Intro Animal Physiology (3 cr)
CHEM	2514	Survey of Organic Chemistry (3 cr)
CHEM	2535	Organic Chemistry (3 cr)
CHEM	2536	Organic Chemistry (3 cr)
CHEM	4615	Physical Chemistry for the Life Sciences I (3 cr)
CHEM	4616	Physical Chemistry for the Life Sciences II (3 cr)
*NEUR	4454	Neuroeconomics (3 cr)
*NEUR	3064	Educational Neuroscience (3 cr)
*NEUR	4084	Developmental Cognitive Neuroscience (3 cr)
*NEUR	4994	Undergraduate Research (up to 3 credits)
PHYS	4714	Introduction to Biophysics (3 cr)
PSYC	2044	Psychology of Learning (3 cr)
PSYC	2064	Nervous Systems and Behavior (3 cr)
PSYC	4044	Advanced Learning (3 cr)
PSYC	4114	Cognitive Psychology (3 cr)
PSYC	4074	Sensation and Perception (3 cr)
PSYC	4064	Physiological Psychology (3 cr)
STAT	3424	Statistical Neuroscience and Image Analysis (3 cr)
STAT	4204	Experimental Design (3 cr)

***Indicates new course**

Free Electives (26 credits, or 25 credits if taking the ISC—see NOTE below)

Neuroscience students who also wish to prepare for advanced professional school education and training (e.g., medicine, veterinary medicine, dentistry) should consult the recommendations for coursework selection through electives that is provided by the Division of Student Affairs Career Services, through their Pre-Professional Advising program.

NOTE regarding the "ISC": As an alternative entry point to the degree program, students can participate in the Integrated Science Curriculum or "ISC" (www.science.vt.edu/isc) offered by

the College of Science at Virginia Tech, rather than the introductory science, math and statistics courses listed above. The ISC is an 8-credit classroom/laboratory experience for a total of four semesters, totaling 32 credits. Upon acceptance of their application, students will follow the Integrated Science Course (ISC) sequence:

ISC 1105, 1115: Integrated Science (8 credits)
ISC 1106, 1116: Integrated Science (8 credits)
ISC 2105, 2115: Integrated Science (8 credits)
ISC 2106, 2116: Integrated Science (8 credits)

BIOL 1105-1105, 1115-1116, CHEM 1035-1036, 1045-1046, PHYS 2205-2206, and STAT 3615 can be substituted with ISC 1105-1106, 1115-1116, 2105-2106, 2115-2116.

Relevance to university mission and strategic planning

How the degree relates to the university mission and strategic planning?

The degree relates strongly to the university's mission. The proposed degree moves Virginia Tech one step further along its continuous public land-grant university mission toward "the discovery and dissemination of new knowledge". The degree will provide a fruitful, interdisciplinary platform for faculty and students to engage through teaching and learning, research and discovery, and outreach and engagement. Our goal with the proposed degree in Neuroscience is to build in this opportunity at every level of instruction and mentorship of students, to ensure that our graduates go on to truly "advance social and community development, foster economic competitiveness, and improve the quality of life" for the citizens of Virginia, the US, and the world. The B.S. Neuroscience degree program will establish Virginia Tech and the Commonwealth as key leaders in education for one of the most critical areas of integrative science of the future. The program ties in with a major research focus area for the College of Science and the university, and it involves undergraduate students in those research efforts that are creating new knowledge in the area of neuroscience.

With regard to the university's 2012-2018 Strategic Plan (http://www.president.vt.edu/strategic-plan/strategic-plan.html), a major thrust is to foster "the life of the mind" by "inspiring creativity, curiosity, and critical thinking". Through the curriculum described, the Neuroscience degree directly addresses the principal strategies in the strategic plan, including: increasing involvement in research/experiential learning; integrating digital fluency for using complex data sets across a variety of disciplines (e.g., exposure to use of large datasets in neurobiology, cognitive neuroscience, and modeling); and implementing alternative pathways for general education (e.g., traditional and integrated science curriculum in the proposed degree). Through its involvement of students in laboratory experiences and exposure to neuroscience research at Virginia Tech beginning in the sophomore year and continuing through the end of the degree, the Neuroscience degree program exemplifies the "hands-on, minds-on" model of education called for in the Virginia Tech strategic plan. Furthermore, the strategic plan identifies science, technology, engineering, mathematics and health sciences (STEM-H) as a key focus area of education, all of which align with the development of the Neuroscience degree. The strategic plan also states that the university will leverage existing and emerging strengths in areas such as health sciences, which is going to be positively impacted by neuroscience education and research.

Justification for the proposed program

We are proposing a four-year Bachelor of Science (B.S.) degree program in Neuroscience to prepare students as future professionals who will be able to address the federal government's continuous call for solutions to the STEM-H (science/technology/engineering/mathematics/ health) "pipeline crisis", as highlighted above in the section on Program Background.
One of the major justifications for the proposed degree is to offer a new opportunity for undergraduates that involves *high-quality integrated science education and training*. The main advantage of the proposed degree is its interdisciplinary nature—an advantage that addresses demand from workforce and graduate/professional school markets that increasingly are seeking graduates with strong interdisciplinary backgrounds in STEM-H that will be able to "hit the ground running" in their new jobs and post-graduate education programs. These students will be exposed to a wide range of disciplines within and outside of the College of Science in a more integrated way. Because of the integrated interdisciplinary nature of the degree, neuroscience graduates will be proficient in understanding molecular, structural, physiological, cognitive, and behavioral aspects of the central and peripheral nervous systems in non-human animals and humans that is fundamental to launching them into successful STEM-H careers.

More specifically, through the proposed curriculum, as well as practical applications and research training, students will become conversant with the theories and methods of molecular, biochemical, cellular and systems as they contribute to the understanding of: anatomical structures, physiological functioning, information processing, adaptive and maladaptive cognitions/emotions/behaviors, disorders and diseases of the nervous system, and clinical/biomedical applications. *This portfolio of skills will ensure that graduates of the Neuroscience degree program are highly competitive for the employment markets* in research (both industry and government), medical pharmaceutical and device development and sales, and graduate (e.g., MA/MS, Ph.D.) and professional (e.g., LD, MD) degree programs that either directly or indirectly pertain to Neuroscience. Details on careers are provided in "Market Demand" below.

The interdisciplinary nature of the degree also will address student demand and *reap benefits for students' curiosity and learning.* There is strong student demand for a neuroscience degree at Virginia Tech, as detailed below. There is widespread interest in the nervous system's structure and function among many of the students and faculty in diverse departments within and outside of the College of Science at Virginia Tech. Given that this will be one of only a few truly interdisciplinary undergraduate degrees in science and mathematics in the Commonwealth, the degree will provide a unique and highly desired platform for study that will attract a diverse body of students from Virginia. The degree program will provide opportunities for in-state and out-of-state students to benefit directly from the rapid and exciting growth in neuroscience occurring at Virginia Tech. Students will take classes with scientists from a variety of backgrounds and disciplines, and will learn cutting edge neuroscience theory, research methods, and practical applications. Also, by engaging in research and practical experience as part of the proposed degree, students also will be able to capitalize on the growth in neuroscience applications and research within the college and elsewhere at VT including the Virginia Tech Carilion Research

Institute. The time is right to launch a new interdisciplinary degree program that will reduce the likelihood of students in Virginia leaving the state to get this training, and will increase the likelihood that graduates of the program will remain in the state as they launch their careers.

Student Demand

There is strong student demand for an undergraduate neuroscience specific degree at Virginia Tech. This demand comes not only from current undergraduate students but also includes interest from high-school seniors who have applied or are thinking about applying to Virginia Tech. In 2013, the office of the College of Science has received over 100 requests for information regarding the formation of the neuroscience undergraduate degree. This includes e-mails, office visits, phone calls, and requests from both visiting prospective students and prospective transfer students. The typical requestor has heard that VT is developing a neuroscience degree and is excited to find out when it will be available for transfer or enrollment. Representative e-mail's from two students (one interested in transferring from a current major and one interested in transferring from a different institution) capture the excitement for this new major from the student perspective.

> *"Hello, my name is Laura Smith and I am inquiring about your neuroscience division at Virginia Tech. I am not a current student but I am very interested in attending your school. I am interested in pursuing neuroscience and I found the page on VT website for the divison, however it is not listed as a major on the list of majors. Does Virginia Tech offer neuroscience as a degree I could apply for? Thank you."*
>
> - Laura, Potential Student

> *"I was very excited to hear about the new Neuroscience major, and was hoping that you would be able to point me in the right direction for what I should do next. I am currently a sophomore in University Studies that is looking to pursue a career in medicine, and I believe a major in Neuroscience would fit my interests perfectly.*
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> *Should I speak with an advisor in the College of Science? Or is there a meeting for students wanting to transfer to this major? Any information would be greatly appreciated."*
>
> Best regards, Kimberly

Enrollment in core curriculum courses: We piloted the Introduction to Neuroscience courses in Fall 2012 and Spring 2013, which included 35 students in the Fall and 15 students in the Spring semester. Enrollment for the Fall 2013 course is 45 students, and enrollment for the new Neuroscience lab course for Fall 2013 is 18 students.

Market Demand

Neuroscience comprises a broad range of disciplines, which at its most fundamental level, reveals how the brain works. This fundamental level can be expanded into disciplines that further examine how the brain dictates movement and sensation, decision-making and emotions, societal interactions, and human motivation. Neuroscience is, by its very nature,

interdisciplinary and reveals who we are, what we do and what makes us tick. Now more than ever, fundamental and applied principles of neuroscience are being used in our everyday lives and the success of future managers, entrepreneurs, doctors, scientists and industry leaders depends on – at minimum – a basic understanding of the individuals with which they manage, market to, and influence.

Neuroscience principles are being applied in almost all aspects of business. Companies like Match.com™ are already using behavioral data to match individuals based on compatibility while companies like Pymetrics™ have gone a step further to use classical neurobehavioral response paradigms to match potential employees to employers.[2] The potential market for technologies that involve understanding, manipulating, assessing, or informing the brain is enormous. A recent Forbes article[3] sums up the market potential for neuroscience-based innovation this way:

"The message is clear: The new frontier is inner space. Companies that effectively match emerging knowledge about the brain with profound human needs have a shot at striking gold."

All this brain-based innovation is being driven by a combination of private and federal investment, with companies like Google (Google has recently made major improvements to its speech recognition using new techniques based on models inspired by biological neurons)[4] : "Google is now using these neural networks to recognize speech more accurately, a technology increasingly important to Google's smartphone operating system, Android, as well as the search app it makes available for Apple devices (see "Google's Answer to Siri Thinks Ahead"). "We got between 20 and 25 percent improvement in terms of words that are wrong," says Vincent Vanhoucke, a leader of Google's speech-recognition efforts. "That means that many more people will have a perfect experience without errors." The neural net is so far only working on U.S. English, and Vanhoucke says similar improvements should be possible when it is introduced for other dialects and languages."

Likewise, Microsoft's co-founder Paul Allen is investing heavily in neuroscience translational and behavioral research.[5] The federal push for neuroscience translational research and funding is being spearheaded by several federal entities including President Obama, Senator Fattah, and the NIH. The key message here is translation. The majority of this investment is targeting research that can be rapidly translated to the marketplace. This means that sooner, rather than later, there

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[2] www.pymetrics.com. Pymetrics brings the next technological and scientific advancement in human capital management: neuroscience-based assessment and development. Our assessment identifies potential employee cognitive, personality and socioemotional style.

[3] This Is Your Brain On Business: Neuroscience Creates Opportunities For Innovation, Forbes 10/17/2011, http://www.forbes.com/sites/tedgreenwald/2011/10/17/this-is-your-brain-on-business-neuroscience-creates-opportunities-for-innovation/ accessed 11/23/2013

[4] Google Puts Its Virtual Brain Technology to Work
A powerful new approach to artificial intelligence is ready to improve many Google products. MIT Technology Review http://www.technologyreview.com/news/429442/google-puts-its-virtual-brain-technology-to-work/?a=f Accessed 11/23/13

[5] Microsoft Co-Founder Paul Allen Invests $300 Million Into Mapping the Brain, Popular Science, http://www.popsci.com/science/article/2012-03/microsoft-co-founder-paul-allen-injects-another-300-million-his-brain-research-institute Accessed 11/23/13

will need to be an undergraduate level workforce that is educated in the fundamentals of neuroscience in order to provide this bench to marketplace translation.

Moreover, the emerging importance of neuroscience has recently been highlighted by the White House as revealed by both the appointment of an Interagency Working Group on Neuroscience (IWGN) and the announcement of the BRAIN (Brain Research through Advancing Innovative Neurotechnologies) initiative. This initiative represents a $3 billion dollar ($300 million dollar per year for 10 years) effort to increase brain research and innovation across multiple disciplines to understand not only fundamental function of the brain, but also the effects that learning, cognition, and education might have on society, behavior and the economy *writ large*. Specifically the IWGN (http://www.whitehouse.gov/sites/default/files/iwgn_charter.pdf) reported that:

"The conferees believe there is a potential in the near future for significant, transformative advances in our fundamental understanding of learning, brain development, brain health and recovery. Such advances will require enhanced tools to better understand the working of the brain, enhance data and data infrastructure, and expand interdisciplinary and large-scale research efforts." (p. 4)

One of the major reasons that both commercial companies and federal agencies are investing so heavily into neuroscience however is because there is a growing market demand for neuroscience-based products, which directly translates into sales and jobs. While it appears that the aforementioned investments are targeting only those who might obtain a higher degree (research scientists, etc), the demand for undergraduates with knowledge of neuroscience will increase as a result of this funding.

The NIH estimates that for every $1 spent on medical research funding, there is a $2.2 windfall in economic growth. This type of economic growth is usually realized in the small business sector which typically employees greater than 52% of the workforce and is responsible for most of the economic recovery seen after the last recession. In support of this and with emphasis on the role of an emerging neuroscience marketplace, a search of small business innovative research grants (SBIRs) demonstrates that since 2000, 1585 SBIRs have been awarded for topics relating to the brain. Of these, 155 (or 9.7%) were awarded in 2012. In fact, only 8 SBIRs for brain related topics were awarded in the year 2000. The explosion of awards for small businesses is a good indication of the impact that this level of funding can have on the economy *writ large*.

Entire industries will be created based on the research that is currently being funded at the upper levels of academics. Preparing undergraduates for these future careers is paramount in enabling them to capture the future economic opportunities that neuroscience has to offer the undergraduate. A recent report by the Science Coalition[6] put it this way:

"There is no question that when the federal government invests in scientific research there is a tremendous return. Knowledge is gained; discoveries are made with profound implications for our health, safety and quality of life; future scientists, doctors, teachers and leaders are educated;

[6] The Science Coalition (http://www.sciencecoalition.org/reports/Sparking%20Economic%20Growth%20FINAL%2010-21-13.pdf)

innovations give birth to new technologies, companies and industries; and jobs are created. All of this activity advances our economy and global competitiveness." (p. 2)

Undergraduates with a degree in neuroscience are poised to either immediately enter the marketplace or graduate school. Due to the increase in both commercial and federal funding, undergraduates with a background in neuroscience will have opportunities directly out of Virginia Tech.

Employment Demand

Recent data from Simply Hired shows that of the jobs that are currently listed specifically for "neuroscience", 49% of those call for a bachelors level degree (see figure 1). These jobs vary across industry but already reflect the need for neuro-specific training at an undergraduate level. These jobs are typically in the management, sales, or marketing of neuro-based products and request young talent with background in neuroscience training.

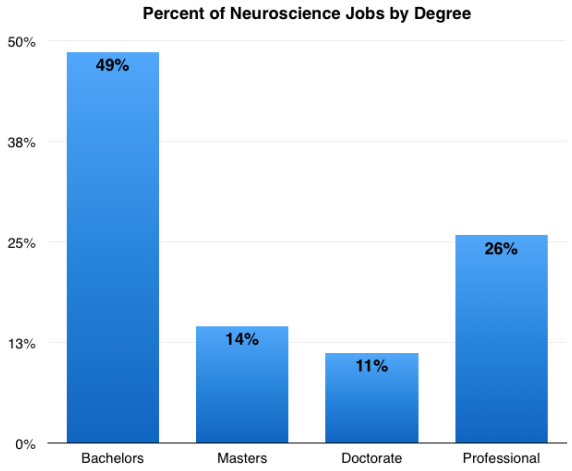


Figure 1: Number of Neuroscience Jobs available through SimplyHired.com that specifically list Neuroscience as a degree preference

If we expand this to include all potential jobs available to undergraduate neuroscience majors (including those available to traditional biology majors), the undergraduate job demand through 2020 is even better.

While neuroscience jobs have yet to be categorized as an individual data point by the Bureau of Labor Statistics (BLS), this bureau maintains information on job labor markets, and fields, that represent career choices for neuroscience undergraduate degree holders. The tables below (Table 1 for national data, Table 2 for Commonwealth of Virginia data) highlight the job projections (number of available jobs) up through CY2020. These tables include jobs that would be eligible for students with a neuroscience undergraduate degree *with no further advanced degree*.

An analysis of neuroscience related job postings since 2009 reveals that the NS related job market is increasing in Virginia (see Figure 2 below). Since a low in November of 2009 (39,305 ads), neuroscience related job postings in VA have increased by 85% to 72,841, hitting a 4-year high in July 2013. Potential job opportunities in the state include a mix of opportunities for individuals with both an undergraduate degree in neuroscience (community and social services occupations; education, training and library sciences occupations; healthcare support occupations; personal care and service occupations; and technical scientific sales and related occupations) and a graduate degree in a related science (life, physical, and social science occupations; legal occupations; healthcare practitioners and technical occupations). Of these, the two fastest growing sectors that represent viable options for neuroscience majors include

technical scientific sales and related occupations (growing at 95% since 2009) and education, training and library science occupations (growing at 59%).

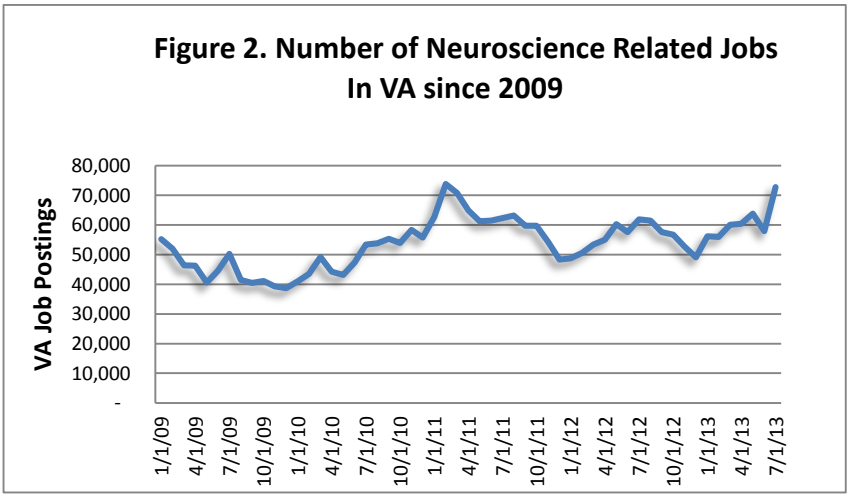
Table 1: Job Growth Projections (2010-2020) for Neuroscience-Related Occupations (U.S. Bureau of Labor Statistics; http://www.bls.gov/ooh)

Job Title	SOC Code	Employment 2010	Projected Employment 2020	Percent Change 2010-20
Biological Technician	19-4021	80,200	91,100	14%
http://www.bls.gov/ooh/Life-Physical-and-Social-Science/Biological-technicians.htm				
Biomedical Engineer	17-2031	15,700	25,400	62%
http://www.bls.gov/ooh/architecture-and-engineering/biomedical-engineers.htm				
Forensic Science Tech	19-4092	13,000	15,400	19%
http://www.bls.gov/ooh/life-physical-and-social-science/forensic-science-technicians.htm				
Health Educators	21-1091	63,400	86,600	37%
http://www.bls.gov/ooh/Community-and-Social-Service/Health-educators.htm				
Medical and Clinical Laboratory Technologists	29-2011	169,400	188,600	11%
http://www.bls.gov/ooh/Healthcare/Medical-and-clinical-laboratory-technologists-and-technicians.htm				
Sales, Technical and Scientific Products	41-4011	400,000	465,500	16%
http://www.bls.gov/ooh/sales/wholesale-and-manufacturing-sales-representatives.htm				

Table 2: Job Growth Projections (2010-2020) for Neuroscience-Related Occupations (Virginia Employment Commission)

Job Title	SOC Code	Employment 2010	Projected Employment 2020	Total Percent Change	Annual Percent Change
Biological Technician	19-4021	953	1079	13.2%	1.2%
Biomedical Engineer	17-2031	462	905	95.9%	7%
Forensic Science Tech	19-4092	374	415	11%	1%
Health Educators	21-1091	1,289	1,716	33%	2.9%
Medical and Clinical Laboratory Technologists	29-2011	4,152	4,733	14%	1.3%
Sales, Technical and Scientific Products	41-4011	8,809	10,954	24.4%	2.2%

Finally, in September 2013, we conducted an online national search for neuroscience and neuroscience-related job advertisements, which revealed strong demand. Ads for jobs that included the keyword "neuroscience" in the title ranged from ~4,400 to 15,800 nationally. Increasing our search to jobs that were related to neuroscience using the search term "neuro*" increased this to between 25,000 and 117,300 ads. A review of historic data reveals that over the past month, jobs in neuroscience (using the neuro* search term) have increased at a weekly rate of between 6 and 25 percent.[7] Companies that hire neuroscientists (increasingly at the undergraduate level) include local and regional hospital and research groups, universities and colleges, and large conglomerates such as Johnson and Johnson, Allergan, and the large pharmaceutical companies. While not all of these jobs are tagged in a way that allows for specific discrimination of degree requirements, the cross-section that does allow this level of granularity indicates that 49% of these jobs are available for those with undergraduate degrees (see figure 1 above).



Resource Needs/Savings

The newly created Neuroscience courses will be delivered by the departments of Biological Sciences, of Economics, of Statistics, and of Psychology. It is anticipated that in addition to faculty who are now teaching new neuroscience courses, three new hires at the assistant professor rank in the fields of neurobiology, behavioral neuroscience, and neuroeconomics will be assigned to the program. These faculty members will be housed jointly within the Academy of Integrated Science and the Departments of Biological Sciences, Psychology, and Economics. These hires are associated with re-distribution of faculty positions within the College of Science. The College of Science initiated cluster hiring in 2004 as a means of strategically re-aligning resources to better meet the needs of the university, of positioning the College to address interdisciplinary grand challenges in science, and of educating our students in a more comprehensive manner. Hiring in clusters, rather than specific disciplines, is a strategy for the college to seek and acquire the best faculty to promote our research and educational agenda and thereby achieve a stronger institution. Reallocation/realignment of resources to make faculty hires in Neuroscience is a continuation of our on-going strategic initiatives.

Four graduate teaching assistants (GTAs) will adequately cover the laboratory courses as well as the recitation sections throughout the curriculum.

[7] Indeed search term Neuroscience USA = 4,433, Neuro* = 28,070 with 1,776 new postings per week or 6 % growth, Simply Hired Neuroscience USA = 15,810, Neuro* = 117,323 with 57,920 in the last month or 25% per week growth

No additional library or telecommunication resources will be required for the program beyond those that already exist.

In terms of space and equipment, we will be using a synergistic combination of existing resources, which includes faculty research laboratories and existing teaching laboratory spaces:

- The college has recently constructed three dynamic, interdisciplinary lab spaces which will be shared in the initial stages of the program. This space is uniquely positioned within the Biological Sciences and adjacent to the Physics department.
- The laboratory space that is available to Neuroscience students comprises chemical hoods, instrumentation, team bench spaces, cell culture facilities, and team data discussion spaces.
- The university has instituted a mechanism by which lab fees can be collected to help maintain equipment and supplies.
- As the program matures, the expectation is that the planned science research lab building will house these laboratory courses.

RESOURCE	ESTIMATED COSTS (NA: not applicable)
Faculty	$331,500 (salary and benefits for 3 positions)
Administrative Staff	NA
Graduate Teaching/ Graduate Research Assistants	$113,564 (stipend, benefits, and tuition for 4 positions)
Space	NA
Library	NA
Equipment	$690,000 (part of startup)
Other	NA

COLLEGE OF SCIENCE
BACHELOR OF SCIENCE in NEUROSCIENCE
Major in Neuroscience

For Students Graduating in Calendar Year 2016

Name: _____ **Student ID # _____**

CURRICULUM FOR LIBERAL EDUCATION (CLE) REQUIREMENTS

CLE AREA	Title	Credits
Area 1 (6 credits)	**Writing and Discourse**	3 ___3 ___
Area 2 (6 credits)	**Ideas, Cultural Traditions and Values**	3 ___ 3 ___
Area 3 (6 credits)	**Society and Human Behavior**	3 ___ 3 ___
	Psyc 2004 and one other 3-credit course	
Area 4 (8 credits)	**Scientific Reasoning and Discovery**	3 ___ 3 ___
		1 ___ 1 ___

Complete 8 credit hours (6 lecture + 2 lab) of Biology:
*BIOL 1105-1115 AND 1106-1116 (Principles) OR
BIOL 1005-1015 AND 1006-1016 (General) only if hours transferred in upon admission or were taken here for a different major

Area 5 (6 credits)	**Quantitative and Symbolic Reasoning**	3 ___ 3 ___
*MATH 1205-1206		
Area 6 (3 credits)	**Creative and Aesthetic Experience**	3 ___
Area 7 (3 credits)	**Critical Issues in Global Context**	3 ___
	Subtotal	**38**[1]

[1] Certain Area 7 courses also count as Area 2 or restricted elective courses. See CLE Guide for Area 2/Area 7 courses.

MAJOR REQUIREMENTS

8 credit hours (6 lecture + 2 lab) of Chemistry:
*CHEM 1035-1045 AND 1036-1046 OR 3 ___ 3 ___
CHEM 1015-1025 AND 1016-1026 only if hours transferred in upon admission
or were taken here in a different major 1 ___ 1 ___

6 credit hours of Statistics: STAT 3615*-3616 3 ___ 3 ___
Students who wish to specialize in statistics for neuroscience beyond this 6-credit requirement can also take STAT 3424[#] as a restricted elective

6 credit hours of Physics: *PHYS 2205-2206 3 ___ 3 ___

Neuroscience Core Requirements
9 credit hours, Introduction to Neuroscience Courses and Labs:

NEUR 1004 Neuroscience Orientation Seminar (1 cr) 1 ___
NEUR 2025-2026 Introduction to Neuroscience (6 cr) 3 ___ 3 ___
NEUR 2035-2036 Neuroscience Lab (2 cr) 1 ___ 1 ___

15 credit hours, 3000- and 4000-level Neuroscience courses:

NEUR 3044 Cellular and Molecular Neuroscience (3 cr) 3 ___
NEUR 3084 Cognitive Neuroscience (3 cr) 3 ___

NEUR 4034 Clinical Neuroscience (3 cr) 3 ___
NEUR 4044 Neuroscience Senior Seminar (3 cr) 3 ___
NEUR 4054 Neuroscience Research/Practical Experience (3 cr) 3 ___

Subtotal 44

RESTRICTED ELECTIVES

12 credits (at least 6 credits must be at 4000-level), selected from the list below (note that 4000-level courses often have prerequisites so plan restricted elective coursework accordingly)

_____ _____ 3 ___ 3___
_____ _____ 3 ___ 3___

#ALS 2304 Comparative Animal Physiology and Anatomy (4 cr)
#ALS/BIOL 4554 Neurochemical Regulation (3 cr)
#BIOL 2104 Cell and Molecular Biology (3 cr)
#BIOL 3404 Intro Animal Physiology (3 cr)
#CHEM 2514 Survey of Organic Chemistry (3 cr)
#CHEM 2535 Organic Chemistry I (3 cr)
#CHEM 2536 Organic Chemistry II (3 cr)
#CHEM 4615 Physical Chemistry for the Life Sciences I (3 cr)
#CHEM 4616 Physical Chemistry for the Life Sciences II (3 cr)
#NEUR 4454 Neuroeconomics (3 cr)
#NEUR 3064 Educational Neuroscience (3 cr)
#NEUR 4084 Developmental Cognitive Neuroscience (3 cr)
#NEUR 4994 Undergraduate Research (no more than 3 credits count toward this requirement)
#PHYS 4714 Introduction to Biophysics (3 cr)
#PSYC 2044 Psychology of Learning (3 cr)
#PSYC 2064 Nervous Systems and Behavior (3 cr)
#PSYC 4044 Advanced Learning (3 cr)
#PSYC 4114 Cognitive Psychology (3 cr)
#PSYC 4074 Sensation and Perception (3 cr)
#PSYC 4064 Physiological Psychology (3 cr)
#STAT 3424 Statistical Neuroscience and Image Analysis (3 cr)
#STAT 4204 Experimental Design (3 cr)

Subtotal 12

FREE ELECTIVES

25*-26 credits, free electives: to bring total to 120 credits

_____ (cr) _____ (cr)
_____ (cr) _____ (cr)
_____ (cr) _____ (cr)
_____ (cr) _____ (cr)

*For students in the Integrated Science Curriculum (ISC) program
BIOL 1105-1105, 1115-1116, CHEM 1035-1036, 1045-1046, PHYS 2205-2206, and STAT 3615 can be substituted with ISC 1105-1106, 1115-1116, 2105-2106, 2115-2116.

Graduation Requirements: In addition to completing Required Courses listed on the first and second page (with restricted electives courses being selected from those on the list on page 3), each student must have a minimum overall GPA of 2.0 and a minimum in-major GPA of 2.0. For purposes of GPA computation, courses IN-MAJOR will include MAJOR REQUIREMENTS and RESTRICTED ELECTIVES listed on pages 1-2.

Foreign Language Requirement: In order to graduate, students must meet a language study requirement. The College of Science requires three units of a single foreign or classical language (or American Sign Language) during high school or the second semester of a college-level foreign or classical language (or American Sign Language). These credit hours do not count toward the total minimum hours required for the declared degree program.

Progress Towards Degree Policy: Upon the completion of 72 credits, NEUR students must have completed CHEM 1036 and 1046, BIOL 1106 and 1116, and NEUR 2025 and 2026; have a minimum overall GPA of 2.0; and have completed at least 24 credits that apply to the University Curriculum for Liberal Education requirements.

[#]**Prerequisites:** This check sheet contains courses that have at least one prerequisite that is not included as part of this degree. Please see your advisor or consult the Undergraduate Course Catalog for more information.

VirginiaTech
College of Science

Department of Biological Sciences
2125 Derring Hall (MC 0406)
Blacksburg, Virginia 24061
540/231-8930 Fax: 540/231-9307
E-mail: winkel@vt.edu; rawalker@vt.edu
www.biol.vt.edu

To: University Curriculum Committee
Re: B.S. Degree in Neuroscience

Date: December 10, 2013

The Department of Biological Sciences supports approval of the Neuroscience B.S. degree proposal, as well as the use of four BIOL courses (1105, 1115, 1106, 1116) as degree requirements, and two BIOL courses (2104, 3004) as restricted electives. We will accept Neuroscience students into these courses subject to available resources. Biological Sciences faces enrollment pressures on many 1000 and 2000 level BIOL classes, and seat availability remains dependent on continued enrollment support. As long as sufficient enrollment support is provided, and the Neuroscience degree program does not grow beyond 20-25 students per year, these BIOL courses should be able to accommodate Neuroscience students.

The Department of Biological Sciences understands that the Neuroscience degree program will be administered through the Academy of Integrated Science within the College of Science, and that the Academy is responsible for program administration including NEUR course scheduling and student advising. Program oversight, including performance tracking and consideration of programmatic changes as needed, will be provided by the Executive Committee of the Academy's Neuroscience Division, to include one Biological Sciences faculty member.

Sincerely,

Brenda S.J. Winkel
Department Head

Richard A. Walker
Associate Head

VirginiaTech
College of Science

Robert S. Stephens, PhD
Department of Psychology
A University Exemplary Department
109 Williams Hall (MC 0436)
890 Drillfield Drive
Blacksburg, Virginia 24061
540/231-6304 Fax: 540/231-3652

December 10, 2013

To: University Curriculum Committee (UCC)
Re: B.S. Degree in Neuroscience

The Department of Psychology supports the Neuroscience degree proposal, and requests that it be approved by UCC. Our department is pleased to be a part of this exciting educational initiative that promises to produce graduates with skills valuable to the advancement of science, of industry, and of societal well-being.

The Neuroscience degree proposal lists several Psychology courses as part of the restricted electives. We support the inclusion of these courses as part of the Neuroscience degree program, and will accept Neuroscience students into these courses subject to available resources. Psychology does face enrollment pressures on its undergraduate classes, but as long as enrollment support keeps pace with increasing enrollments, and provided the Neuroscience degree program does not grow much beyond its projected size, these courses should be able to accommodate Neuroscience students.

The Psychology Department understands that the Neuroscience degree program will be administered through the Academy of Integrated Science within the College of Science, and that the Academy is responsible for program administration including course scheduling and student advising. Program oversight, including performance tracking and consideration of programmatic changes as needed, will be provided by the Executive Committee of the Academy's Neuroscience Division, to include one Psychology faculty member.

Robert Stephens, Department Head, Department of Psychology — Date

VirginiaTech

Eric P. Smith
Department of Statistics
Virginia Tech
Blacksburg, Virginia 24061
540/231-5657 Fax: 540/231-3863
E-mail: epsmith@vt.edu
www.stat.vt.edu

To: University Curriculum Committee
Re: B.S. Degree in Neuroscience

The Statistics Department wishes to express its support for the Neuroscience degree proposal, and requests that it be approved by UCC. Our department is excited to be a part of this exciting educational initiative that promises to produce graduates with skills valuable to the advancement of science, of industry, and of societal well-being.

The Neuroscience degree proposal lists STAT 3424 and 4204 as part of the restricted electives. We support the inclusion of these courses as part of the Neuroscience degree program, and will accept Neuroscience students into these courses subject to available resources. Statistics does face enrollment pressures on its undergraduate classes, but as long as enrollment support keeps pace with increasing enrollments, and provided the Neuroscience degree program does not grow much beyond its projected size, these courses should be able to accommodate Neuroscience students.

Eric Smith, Department Head
Department of Statistics

12-9-2013
Date

VirginiaTech
College of Science

Department of Chemistry
306 Hahn Hall North (0212)
Blacksburg, Virginia 24061
540/231-5391

December 9, 2013

To: University Curriculum Committee
Re: B.S. Degree in Neuroscience

The Chemistry Department wishes to express its support for the Neuroscience degree proposal, and requests that it be approved by UCC. Our department is excited to be a part of this exciting educational initiative that promises to produce graduates with skills valuable to the advancement of science, of industry, and of societal well-being.

The Neuroscience degree proposal lists several CHEM courses as part of the list of restricted electives. We support the inclusion of these courses as part of the Neuroscience degree program, and will accept Neuroscience students into these courses subject to available resources. Chemistry does face enrollment pressures on its undergraduate classes, but as long as enrollment support keeps pace with increasing enrollments, and provided the Neuroscience degree program does not grow much beyond its projected size, these courses should be able to accommodate Neuroscience students.

Regards,

J. M. Tanko
Professor & Chair

VirginiaTech
College of Science

Professor Leo E. Piilonen
The William E. Hassinger, Jr. Senior Faculty Fellow
Chair, Department of Physics
125 Robeson Hall
Blacksburg, Virginia 24061-0435
540/231-7472 Fax: 540/231-7511
E-mail: physics.chair@vt.edu
www.phys.vt.edu

October 22, 2013

Dr. Kirby Deater-Deckard
Department of Psychology
Virginia Tech
0436

Dear Kirby:

We understand that you would like to list PHYS 2205 and 2206 as required courses and PHYS 4714 as a restricted elective for students in the new Neuroscience B.S. degree program.

I support your proposal to list these courses as described above in the new Neuroscience B.S. degree program's checksheet.

Please note that the *current* enrollment capacity in PHYS 2205 and 2206 is presently supported by enrollment support funds from the Provost's office; these support funds have historically been adjusted to match demand. *As long as this support model continues*, i.e., we receive funding from the Provost's office to support the lecture sections for both courses to match enrollment needs and we can identify qualified instructional personnel, the available seats will accommodate all students, including those who enroll in the new Neuroscience B.S. degree. Otherwise, seats will be offered to all qualified students in the College of Science and then in other colleges on a first-come first-serve basis during the course request times.

Sincerely,

Leo Piilonen

Leo Piilonen
Chair, Department of Physics

VirginiaTech

College of Agriculture and Life Sciences
Academic Programs
1060 Litton Reaves (0334)
175 West Campus Drive
Blacksburg, Virginia 24061
540/231-5290 Fax: 540/231-6741
E-mail: sumners@vt.edu

December 11, 2013

To: College of Science Curriculum Committee

Re: B.S. Degree in Neuroscience

The Neuroscience degree proposal lists ALS 2304, Comparative Animal Physiology and Anatomy, and ALS 4554, Neurochemical Regulation, as part of the restricted electives. We support the inclusion of these courses as part of the Neuroscience degree program, and will accept Neuroscience students into these courses subject to available resources. Provided the Neuroscience degree program does not grow much beyond its projected size, these courses should be able to accommodate Neuroscience students.

Sincerely,

Susan S. Sumner
Associate Dean and Director of Academic Programs