RESOLUTION TO APPROVE B.S. IN NEUROSCIENCE

Documents included:

1. Resolution to Approve B.S. in Neuroscience

2. B.S. in Neuroscience Degree Proposal

3. Degree Proposal Presentation – slides

RESOLUTION TO APPROVE BACHELOR OF SCIENCE DEGREE IN NEUROSCIENCE

WHEREAS, neuroscience encompasses rapidly emerging, scientifically critical areas within mathematics, statistics, and computer science; and

WHEREAS, neuroscience represents a unique academic field in that it requires students to understand and utilize diverse knowledge from multiple disciplines; and

WHEREAS, neuroscience has reached a point where a working knowledge of the brain and mind not only has implications in maintaining and improving the health and well-being of the world's citizens, neuroscience research decisions (and implementation) will be impacting society and the world; and

WHEREAS, the bachelor of science in neuroscience will provide students with the theoretical, experimental, statistics, and deductive reasoning skills to excel in integrating molecular, structural, physiological, cognitive, and behavioral aspects of the central and peripheral nervous systems; and

WHEREAS, the bachelor of science in neuroscience will prepare graduates for interdisciplinary research and education, with employment in the private sector, employment in state and federal government agencies, and for post-baccalaureate training; and

WHEREAS, the College of Science is in an excellent position to initiate a bachelor of science in neuroscience in that it draws from the expertise of historically strong departments at Virginia Tech (including biology, chemistry, economics, mathematics, physics, psychology, and statistics), and because of recent additions of junior and senior faculty who are actively engaged in research in neuroscience at molecular, behavioral and cognitive levels and with the addition of the new Virginia Tech Carilion Research Institute (VTCRI); and

WHEREAS, the bachelor of science in neuroscience is one of only four similar undergraduate degrees in the Commonwealth of Virginia, and will be one of the most rigorous interdisciplinary neuroscience programs in the United States, establishing Virginia Tech and the Commonwealth as key leaders in education for one of the most critical technologies of the future;

NOW, THEREFORE, BE IT RESOLVED that the bachelor of science in neuroscience be approved effective fall 2015 and the proposal forwarded to the State Council of Higher Education for Virginia (SCHEV) for approval and to the Southern Association of Colleges and Schools (SACS) for notification.

RECOMMENDATION:

That the resolution to approve the bachelor of science degree in neuroscience be approved.

June 2, 2014

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 (3 cr)
CHEM	4616	Physical Chemistry for the Life Sciences (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.*
>
> *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

[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.

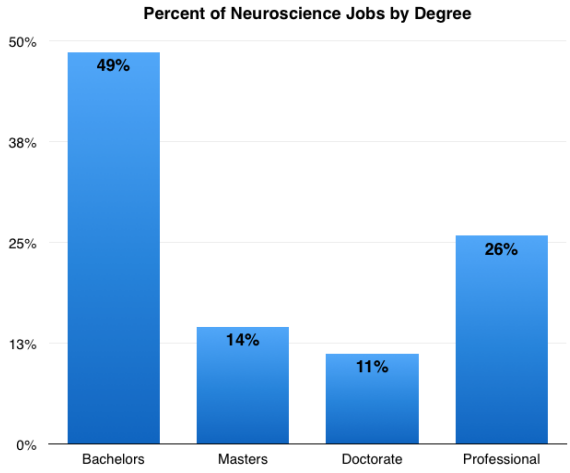


Figure 1: Number of Neuroscience Jobs available through SimplyHired.com that specifically list Neuroscience as a degree preference

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%).

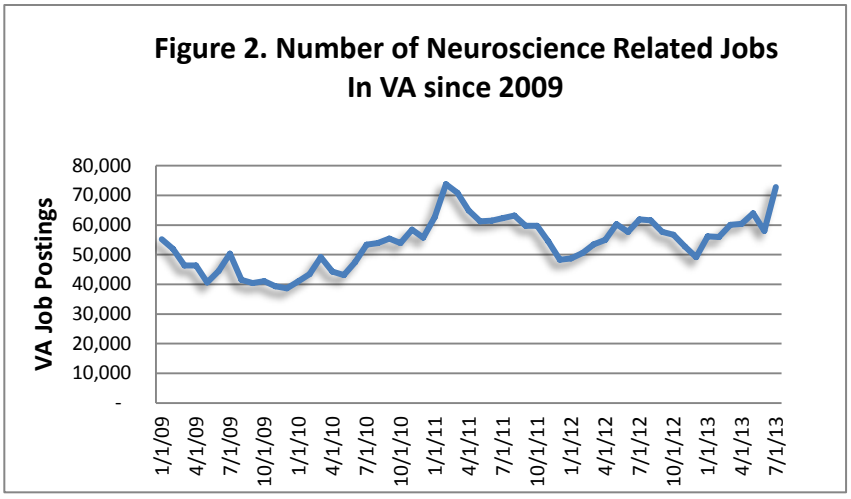
Table 1: Job Growth Projections (2010-2020) for Neuroscience-Related Occupations (U.S. Bureau of Labor Statistics; http://www.bls.gov/ooh)

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.
- Equipment for new faculty, which will also be used by neuroscience students working in their labs, is included under start-up below.
- 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	NA
Other (Faculty Start-up Expense)	$1,650,000

Attachment D

B.S. DEGREE IN NEUROSCIENCE (NEUR)

Kirby Deater-Deckard (Psychology)
Ignacio Moore (Biological Sciences)

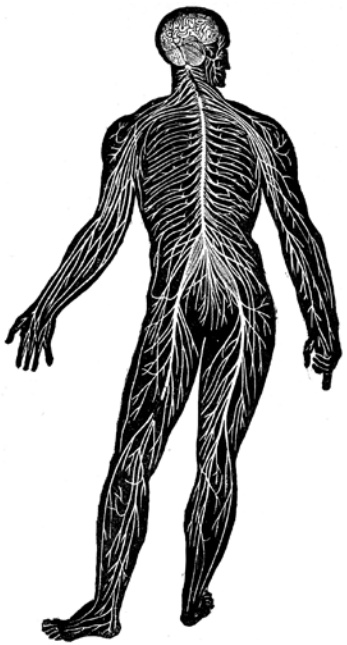
Board of Visitors
Academic Affairs Committee
June 2, 2014

VirginiaTech
Invent the Future

Background

Neuroscience:

- interdisciplinary
- development, structure, function



- understanding of “mind and behavior”
- diagnosis, treatment of many medical and mental disorders

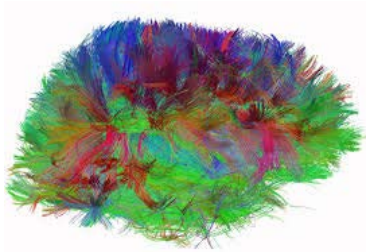
Why is neuroscience important?

- Fundamental to cognition, emotion, behavior
- Complexity, plasticity: signaling, gene-environment interaction

- 1,000+ disorders affect ~$1B globally (World Health Organization, 2007)
- 100M Americans annually = $1B in costs
- President Obama's $100M Brain Research Advancing Innovative Technologies (BRAIN) initiative

Neuroscience @ Virginia Tech: Synergies that benefit undergraduates!

- Growth in neuroscience education and research
- Time to launch degree *for undergraduate students*



Justification and Preparation

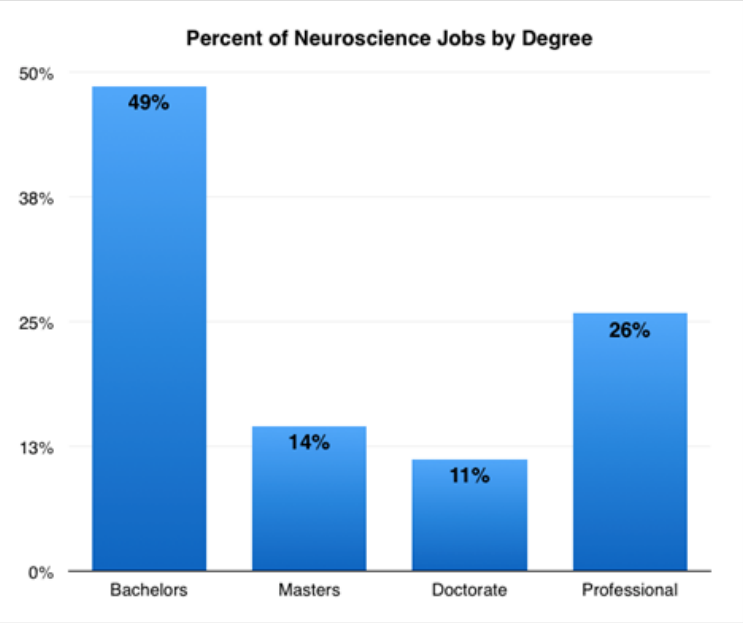
- Mature discipline, key to science, technology, engineering, mathematics, and health (STEM-H)

- High student demand

- Six new courses past two years

- *Hands on, minds on*

  - *Integrate* life/behavioral/math sciences
    - Think and communicate effectively

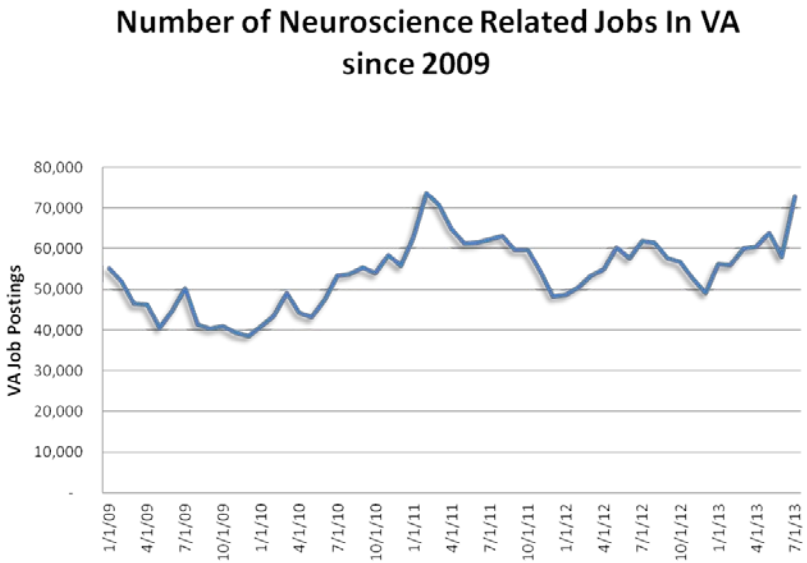


Neuroscience Jobs available through SimplyHired.com that specifically list Neuroscience as degree preference

- Growing employment and grad/prof school demand

Examples:

- Research associate (Allen Inst)
- Medical Lab Tech (VCU)



Degree Program

	Credits
Science/Math Foundations + Curriculum for Liberal Education (CLE):	58
Initial integration from cells to behavior [core]:	15
Applications, further integration (major sub-domains) + advanced integration (specialization) [core + restricted electives]	21
Free Electives:	26
Total:	120

Attachment D

Sample Plan of Study (120 credits in 4 years)

Year	Fall Semester	Spring Semester
Freshman	Principles of Biology I with lab (4)	Principles of Biology II with lab (4)
	General Chemistry I with lab (4)	General Chemistry II with lab (4)
	Calculus I (3)	Calculus II (3)
	Introduction to Psychology (3)	Neuro Orientation Seminar (1)
		Free Elective Course (3)
Total/Sem	**14 credits**	**15 credits**
Sophomore	Introduction to Neuroscience I (3)	Introduction to Neuroscience II (3)
	Restricted Elective Course (3)	Biological Statistics I (3)
	Writing and Discourse (3)	Writing and Discourse (3)
	Ideas, Cultural Trad., and Values (3)	Society and Human Behavior (3)
	General Physics I (3)	General Physics II (3)
Total/Sem	**15 credits**	**15 credits**
Junior	Neuroscience Lab I (1)	Neuroscience Lab II (1)
	Restricted Elective (3)	Cognitive Neuroscience (3)
	Cell and Molecular Neuroscience (3)	Biological Statistics II (3)
	Creativity and Aesthetic Exp (3)	Restricted Elective Course (3)
	Free Elective Course (3)	Free Elective Course (3)
	Free Elective Course (3)	Free Elective Course (3)
Total/Sem	**16 credits**	**16 credits**
Senior	Neuro Research and Practical (3)	Senior Neuroscience Seminar (3)
	Clinical Neuroscience (3)	Restricted Elective Course (3)
	Ideas, Cultural Trad., and Values (3)	Critical Issues in a Global Context (3)
	Free Elective Course (3)	Free Elective Course (3)
	Free Elective Course (3)	Free Elective Course (2)
Total/Sem	**15 credits**	**14 credits**

Foundations

Initial Integration

Adv Integration

& Specialization