Program Approval Form

For approval of new programs and deletions or modifications to an existing program.

Action Requested:

- [ ] Create New (SCHEV approval required except for minors and certificates)
- [ ] Delete Existing
- [X] Modify Existing (check all that apply) – M.S. Biology
  - [ ] Title (SCHEV approval required except for minors, certificates)
  - [X] **Concentration** (Choose one): [X] *Add* [ ] *Delete* [ ] *Modify*
  - [ ] Degree Requirements
  - [ ] Admission Standards
  - [ ] Application Requirements
  - [ ] Other Changes: _____

Type (Check one)**:**

- [ ] B.A. [ ] B.S. [ ] Minor
- [ ] Undergraduate Certificate
- [ ] M.A. [X] M.S. [ ] M.Ed.
- [ ] Ph.D. [ ] Graduate Certificate
- [ ] Other: _____

College/School:	College of Science	**Department:**	School of Systems Biology		
Submitted by:	Daniel N. Cox, Ph.D.	**Ext:**	3-4971	**Email:**	dcox5@gmu.edu

Effective Term: Fall 2013

Please note: For students to be admitted to a new degree, minor, certificate or concentration, the program must be fully approved, entered into Banner, and published in the University Catalog.

Justification: (attach separate document if necessary)

See attached.

	Existing	New/Modified
Program Title: (Required) Title must identify subject matter. Do not include name of college/school/dept.	M.S. Biology	
Concentration(s):		A new concentration in Neuroscience is proposed
Admissions Standards / Application Requirements: (Required only if different from those listed in the University Catalog)		See attached.
Degree Requirements: Consult University Catalog for models, attach separate document if necessary using track changes for modifications		See attached.
Courses offered via distance: (if applicable)		N/A
TOTAL CREDITS REQUIRED:		30

Approval Signatures

Department	Date	College/School	Date	Provost's Office *Interdisciplinary Council Use Only*	Date

If this program may impact another unit or is in collaboration with another unit at Mason, the originating department must circulate this proposal for review by those units and obtain the necessary signatures prior to submission. Failure to do so will delay action on this proposal.

Unit Name	Unit Approval Name	Unit Approver's Signature	Date
Krasnow Institute	James L. Olds, Ph.D.		
Dept. of Psychology	Robert Smith, Ph.D.		

For Graduate Programs Only

Graduate Council Member	Provost Office	Graduate Council Approval Date

Justification for the Proposed Neuroscience Concentration in the M.S. Biology Program

Response to Current Needs

Neuroscience is a large and continually growing field nationally and internationally. In addition to continuing research and evolution of existing neuroscience subfields, new subfields are emerging. One example of a new subfield is neuroengineering - at Mason, a research program is currently being developed to evaluate suitability of novel materials for brain implantation to control prosthetic devices [note added in proof: this has just been funded by a large DARPA grant]. While this is not planned as a focal point of the proposed MS program, a broad knowledge of neuroscience is required to work effectively in this new subfield, even as a high level technician.

Emerging neuroscience at Mason illustrates [and drives] some trends in the field. One such trend might be described as quantitative neuroanatomy. The Ascoli lab has spearheaded a national movement to understand the fine structure of neurons as it determines their functioning, and to develop algorithms describing neural functioning. The Smith/McDonald lab leads the field of using quantitative neuroanatomy to evaluate detrimental effects of drugs during the rat equivalent of adolescence. The Cox lab is likewise a leader in dissecting the molecular mechanisms regulating neural architecture and the relationship between neuron form and function. A number of researchers use the noninvasive imaging facility [fMRI] at Mason to quantitatively evaluate the role of human brain areas in a wide variety of normal and abnormal behaviors, and as ancillary to understanding brain processes underlying phenomena as diverse as human error, human emotion, human perception, human memory and cognitive aging.

Brain cells are essentially cells, as in every other part of the body, that are specialized for information processing. As such, neuroscience itself is a specialization within biology. Each of the above research efforts requires a working knowledge of neuroanatomy [anatomy of the brain] and some quantitative skills, followed by some specialized research skills. Each of them also requires a broad knowledge of neuroscience, in order to understand new findings in the context of the broader knowledge of neuroscience. The proposed program provides those. A required course in neuroanatomy is currently taught by an author of a leading text in comparative neuroanatomy. Other basic biology and neuroscience courses, a statistics course, plus mastery of some specialized methodology for a thesis or project complete the proposed program.

The scope of neuroscience work at Mason goes well beyond research and application of neuroanatomy, however. Neuroscientists use direct electrical measurement techniques to study functioning of nerve cells and of larger areas of brain; a large variety of histological techniques to study cells, their receptors, and other constituent proteins; genomic techniques to evaluate gene expression under different functioning conditions; hemodynamic methods to study blood flow; mathematical modeling of neuronal structure and function; and a number of other techniques. Many of these neuroscience research areas apply standard biological techniques to the nervous system; thus a concentration of neuroscience within the Masters of Biology is eminently sensible. The neuroscience concentration allows students to take cell biology and biochemistry courses that are the foundation of neuroscience, while also taking specialized neuroscience courses. These research areas are all a part of a broad international effort to better understand the functioning of the most complex organ system known: the human brain. That understanding has already led to advances in treatment of many disorders, with the promise of more exciting discoveries on the near horizon.

Current training in neurosciences at Mason mirrors that of most other universities: a relatively new undergraduate program [growing rapidly], plus a PhD program. What is currently lacking at Mason and nearly all other institutions is MS-level training. Many programs award an MS en route to the PhD, but few offer direct-admission programs designed to award the MS as a standalone degree.

The need for training in neuroscience at the MS level begs the question: what can a person with an MS do that a person with a BS in the field cannot? The answer lies in the level of training/knowledge/expertise, and we will organize the differences around the assessment topics to elaborate on this:

- Neuroscience knowledge - the knowledge base of MS graduates will far exceed that of BS students
- Problem solving and written communication skills - it is unusual for an undergraduate to have already developed, designed, conducted and analysed a research project, pursuing it to publishable quality; our MS graduates will have already demonstrated that skill
- Oral communication skills - it is unusual for an undergraduate to have already presented a poster of his/her research findings; our MS graduates will have already demonstrated that they have acquired that skill

In short, our graduates will have demonstrated a higher level of professional knowledge, competence, and skill than is required of undergraduates, positioning them for either continuing training at the MD or PhD level, or responsible mid-level technical positions in research, or responsible managerial positions in industry or government.

Student Demand

An email survey [April, 2011] of students in the recently initiated undergraduate BS neuroscience program at Mason revealed that 62 current students are interested in such a program [Email question to current undergraduate BS Neuroscience students: Mason is preparing to propose an MS in Biology with a concentration in Neuroscience. The proposal would involve 30 credit hours, and would include options of thesis, project, or literature review as a final project. As part of the proposal, we need to demonstrate student interest in the program. Your response is important as part of this [really]. If you THINK you might be interested in such a program, please FORWARD this email to bsmith@gmu.edu, with the message YES. If you would NOT be interested, forward this msg to bsmith@gmu.edu, with the msg NO. With a response rate of 70/140, we received 62 YES responses, 8 NO responses].

A follow-up email survey was conducted in October, 2011. Although the response rate to this followup survey was lower [Question: 1. Are you potentially interested in applying to the proposed MS Biology with a concentration in Neuroscience?; 17 responses received], all 17 students responding indicated an interest in the proposed program, and half requested further information on program specifics [curriculum was provided in the email] and application procedures.

As strong graduate programs typically recruit from well beyond the local area, there is every reason to believe that out-of-area demand will far exceed this number. Nationally, 2,069 undergraduate Neuroscience degrees were granted in 2009, but neuroscience undergraduate programs are relatively new, and graduate programs draw strongly from related fields, such as Biology [80,756 degrees nationally] and Psychology [94,271 degrees], as well as others [source for above numbers: US Dept of Education]. Students with B.A. in psychology will typically pursue an Masters degree in psychology prior to entering the PhD program, but students with a B.S. in Biology currently have no Masters degree option allowing them to focus on Neuroscience. Thus, there is a large pool of prospective applicants; if the response rate from our Neuroscience BS students is a good indicator, demand should be very strong.

Finally, Mason already receives, and denies admission to, a number of inquiries and applicants appropriate to this program. The Biopsychology MA concentration, which has a different curricular

structure and different research mentors for students, typically receives 25-30 applicants per year, and admits 6-8. Of the remainder, the concentration director estimates that at least 50% would be interested in working with research advisors in the proposed Neuroscience MS program; in fact, 2 current Biopsychology students have elected mentors in the Neuroscience program, despite the mismatch of the Biopsychology curriculum with their educational goals – these students are 'crafting' a program from the Biopsychology base, to offset the lack of a real MS Neuroscience program. Similarly, 5 students in Biology are already crafting their own M.S. in Biology with a neuroscience concentration? In addition, the biopsychology concentration director receives about 30 email inquiries per year from students who do not follow up with an admission application; the concentration director estimates that more than half of the 30 had research interests more appropriate to the proposed degree than to the current Biopsychology degree.

Admission Requirements

Prospective students should submit standard application materials, including the university application form, undergraduate transcript(s), General GRE scores, personal statement, and three letters of recommendation. Recommended minima include GRE scores of 1100 on the old scale or approximately 303 on the new scale, an undergraduate GPA of 3.00, strong letters of recommendation, and statement of interests consistent with at least one faculty member's research program. Fulfillment of the minimum requirements does not guarantee admission to the program, as availability of an appropriate mentor will be an important part of the admissions decision. We anticipate many more applicants who exceed minimum requirements than can be admitted.

Degree Requirements

An advisory committee (consisting of three relevant graduate faculty) and the student work together to develop a program of study that best fits the student's background and interests. The student must submit a program of study to the program director for approval within the first 12 credits of graduate work and must complete at least 30 graduate credits.

Students have the option to complete a thesis (3 to 6 credits of BIOL 799) or a research project (1 to 3 credits of BIOL 798). According to Mason graduate policies, the same quality of work is expected of students regardless of their chosen option; that is, the MS thesis option or the MS project option. In general, the MS thesis is most appropriate for students planning or considering a research career. The MS project is most appropriate for students who have scheduling commitments, such as a full-time job, that may preclude performing a complete series of laboratory experiments.

The requirements differ primarily at the conclusion of the project, when students pursuing the project option must successfully complete written and oral comprehensive exams. Students pursuing the thesis option must write a formal thesis that meets the requirements of the graduate school, as well as defending their thesis and presenting their results in a public seminar.

Curriculum

The proposed MS in Biology, Neuroscience concentration program requires 30 credits of graduate coursework. Credits are distributed as follows, with courses already existing designated by an asterisk:

BIOL 690*	Introduction to Graduate Studies	1
NEUR 601*	Developmental Neuroscience	2
NEUR 602*	Cellular Neuroscience	3
NEUR 603*	Mammalian Neurobiology	3
NEUR 604*	Scientific Ethics	3
	OR	
NEUR 702*	Research Methods	3
STATISTICS [several options, see below]*		3
NEUR 709	NEUROCIENCE@GMU*	1
ELECTIVES*/RESEARCH*		5-10
THESIS/PROJECT** - BIOL 798/799		1-6
TOTAL		30

Course descriptions are provided in the appendix, along with a sample schedule. There are no new classroom courses required for the proposed program. Moreover, this proposed curriculum includes the mandatory minima of 12 hours of unique coursework for a given concentration.

**Project: for students not intending bench-level research upon graduation, a non-laboratory project of similar scope to a thesis is an option. This could include work such as a very extensive critical literature review, developing a draft workscope for a grant funding program for a Federal agency, etc.

Appendix A – Course Descriptions

BIOL 690 - Introduction to Graduate Studies in Biology
Credits: 1-2 (NR)

Required of all new MS students in biology.

NEUR 601 - Developmental Neuroscience
Credits: 2 (NR)

Introduction to neurobiology with overview of embryological development of the nervous system in evolutionary context. Regional and systems neuroanatomy introduced by study of the mammalian visual system with a comparative perspective.

Equivalent to PSYC 527

Prerequisite(s): PSYC 372, or BIOL 213 and 303, or the equivalent.

NEUR 602 - Cellular Neuroscience
Credits: 3 (NR)

Detailed overview of the functioning and interactions of the cellular elements of the central nervous system. Topics include structure and function relationships, the chemical, physical, and electrical basis of neural signaling, local versus long-distance signaling, generation of action potentials, and essentials of synaptic communication.

Prerequisite(s): Admission to the PhD program in Neuroscience or permission of instructor.

NEUR 603 - Mammalian Neurobiology
Credits: 3 (NR)

Functional anatomy of the brains of mammals, with emphasis on regional and systems neuroanatomy of humans. Anatomy is correlated with material from clinical neurology where possible. Laboratory component includes brain dissections and clinical correlations.

Equivalent to PSYC 531; BIOL 515

Prerequisite(s): NEUR 601

NEUR 604 - Ethics in Scientific Research
Credits: 1-3 (NR)

Reflects on purpose of scientific research and reviews foundational principles for evaluating ethical issues. Offers skills for survival in scientific research through training in moral reasoning and teaching of responsible conduct. Discusses ethical issues in research, and teaches how to apply critical thinking skills to design, execution, and analysis of experiments. Issues include using animals and humans in research, ethical standards in computer community, and research fraud. Currently accepted guidelines for behavior in data ownership, manuscript preparation, and conduct of persons in authority may be presented and discussed in terms of relevant ethical issues.

Equivalent to PHIL 691

Prerequisite(s): Graduate standing.

NEUR 702 - Research Methods
Credits: 3 (NR)

Trains students in research methodologies, techniques, and data analysis in neuroscience. The course is divided into three modules that introduce separate but equally significant components of any research project. The first module will focus on parameters required for outlining and synthesizing a problem. The second module will cover various techniques of measurement and analysis used by neuroscientists. The last module will cover various approaches used for data analysis and interpretations.

Prerequisite(s): Graduate standing.

NEUR 709 - Neuroscience Seminars
Credits: 1 (NR)

Special seminar series for first year neuroscience PhD students. Detailed overview of neuroscience research at Mason. Each week, a different neuroscience laboratory and principal investigator lectures to students. The lecture includes the neuroscience basics necessary to appreciate the laboratory research theme and mission, and a more practical description of the active research program, possibly including a visit to the laboratory.

Prerequisite(s): Admission to neuroscience PhD program.

STATISTICS OPTIONS:

PSYC 611 - Advanced Statistics*
Credits: 4 (NR)

Test must be passed to take course. Open only to degree students. Integrates basic psychological statistics with overview of research methodology including experimental, quasi-experimental, field approaches, and measurement issues from advanced perspective. Lab work includes using computer packages for data handling and analyses.

Prerequisite(s): Screening test given on first evening of class

Notes: Students must enroll in 611 and 612 in sequential semesters.
* One of a group of courses which can satisfy the requirement

STAT 535 - Analysis of Experimental Data Using SPSS
Credits: 3 (NR)

Statistical methods for analysis of experimental data, including ANOVA and regression. Parametric and nonparametric inference methods appropriate for a variety of experimental designs are presented along with data analysis using SPSS. Intended primarily for researchers in the natural, social, and life sciences.

Prerequisite(s): STAT 250, STAT 344, or equivalent.

Notes: Can be used to satisfy requirements for certificate in federal statistics, but not MS in statistical science. Certificate program students granted credit for only one of STAT 535 or 554.

STAT 544 - Applied Probability
Credits: 3 (NR)

The axioms of probability, conditional probability, random variables and expectation, multivariate and conditional distributions, conditional expectation, order statistics, transformations, moment generating functions, special distributions, limit theorems.

Prerequisite(s): MATH 213 and STAT 346, or permission of instructor.

STAT 554 - Applied Statistics
Credits: 3 (NR)

Application of basic statistical techniques. Focus is on the problem (data analysis) rather than on the theory. Topics include one- and two-sample tests and confidence intervals for means and medians, descriptive statistics, goodness-of-fit tests, one- and two-way ANOVA, simultaneous inference, testing variances, regression analysis, and categorical data analysis. Normal theory is introduced first with discussion of what happens when assumptions break down. Alternative robust and nonparametric techniques are presented.

Prerequisite(s): STAT 346 or permission of instructor.

Notes: Certificate program students granted credit for only one of STAT 535 or 554.

ECE 528 - Introduction to Random Processes in Electrical and Computer Engineering
Credits: 3 (NR)

Probability and random processes are fundamental to communications, control, signal processing, and computer networks. Provides basic theory and important applications. Topics include probability concepts and axioms; stationarity and ergodicity; random variables and their functions; vectors; expectation and variance; conditional expectation; moment-generating and characteristic functions; random processes such as white noise and Gaussian; autocorrelation and power spectral density; linear filtering of random processes, and basic ideas of estimation and detection.

Prerequisite(s): ECE 220 and STAT 346, or permission of instructor.

SUGGESTED ELECTIVES:

BIOL 583 - General Biochemistry
Credits: 4 (NR)

Structure and function of proteins, carbohydrates and lipids, enzymology, and metabolism and its controls. Emphasizes chemistry of nitrogen compounds.

Prerequisite(s): BIOL 213; CHEM 313, 314; or permission of instructor.

BIOL 568 - Advanced Topics in Molecular Genetics
Credits: 3 (RD)

Comprehensive study of regulatory mechanisms controlling gene expression in viruses, prokaryotes, and eukaryotes, emphasizing current research.

Prerequisite(s): BIOL 482, or permission of instructor.

BIOL 682 - Advanced Eukaryotic Cell Biology
Credits: 3 (NR)

Structure and function of biomembranes, cytoskeleton, and transport systems. Also discusses protein trafficking, cell cycle, and cell adhesion molecules.

Prerequisite(s): BIOL 483, CHEM 313, 314; or permission of instructor.

BINF 630 - Bioinformatics Methods
Credits: 3 (NR)

Introduction to methods and tools for pairwise sequence comparison, multiple sequence alignment, phylogenetic analysis, protein structure prediction and comparison, database similarity searches, and discovery of conserved patterns in protein sequence and structures.

Prerequisite(s): Graduate standing, or permission of instructor.

BIOS 741 - Genomics
Credits: 3 (NR)

Genetic structure and function at whole genome level. Includes some sequence analysis, comparative genomics, classical genetics, and developmental genetics, as well as analysis of synteny groups, isochores, gene families, genetic complexity, C value paradox, directed discovery of gene functions, and animal models of human disease. Readings from recent texts and primary research literature. Students expected to give one or two oral presentations of primary research papers, as well as complete midterm and final exams.

Prerequisite(s): At least one undergraduate course in genetics and molecular biology, or permission of instructor.

BIOS 742 - Biotechnology
Credits: 3 (NR)

Theory and applications of biotechnology. Includes promoter design, gene fusions, protein targeting, techniques of protein purification, construction of transgenic organisms, cloning of animals and plants, ethical and legal issues. This is a relatively new area of study that is rapidly changing; course strives to keep students abreast of current literature.

Prerequisite(s): Undergraduate course work in genetics and molecular biology.

BIOS 743 - Genomics, Proteomics, and Bioinformatics
Credits: 3 (NR)

Fundamental methods for analyzing genomic and proteomic data, including nucleic acid and protein sequences, pair-wise and multiple alignment, database search methods, clustering and presentation of data, prediction modeling, and survey of available software and freeware tools.

Prerequisite(s): Admission to biosciences PhD or biology MS program.

BIOS 744 - Molecular Genetics
Credits: 3 (NR)

Develops understanding of principles of modern molecular genetics and methods of investigation of genomes of pro- and eukaryotes, including types of genetic manipulations conducted in research laboratories today.

Prerequisite(s): Undergraduate course work including BIOL 311; CHEM 313, 314, 315, and 318; equivalents; or permission of instructor.

RESEARCH COURSES (ELECTIVE):

BIOL 693 - Directed Studies in Biology
Credits: 1-8 (RD)

Study of topic not otherwise available in graduate program. May involve any combination of reading assignments, tutorials, lectures, papers, presentations, or laboratory or field study, determined in consultation with instructor.

Prerequisite(s): Permission of instructor, chair, and graduate committee.

BIOL 793 - Research in Biology
Credits: 1-3 (RD)

Library, laboratory, or field investigation under supervisor's guidance.

Prerequisite(s): 8 graduate credits in BIOL, and permission of instructor and chair.

Notes: May be repeated for total 3 credits.

Project / Thesis Courses

BIOL 798 - Master's Research Project
Credits: 1-3 (RD)

Experimental or theoretical research project chosen and completed under guidance of graduate faculty member. Comprehensive report acceptable to student's advisory committee is required.

Prerequisite(s): Permission of instructor and department chair.

Notes: Students who take BIOL 793 may not receive more than 6 credits total for both BIOL 793 and 798.

BIOL 799 - Thesis
Credits: 1-6 (RD)

Thesis research under direction of supervisor.

Prerequisite(s): 8 graduate hours in BIOL and permission of instructor.

Notes: Students who take BIOL 793 may not receive more than 6 credits total for both BIOL 793 and 799.

Appendix B – Sample Schedule

Semester I		
BIOL 690*	Introduction to Graduate Studies	1
NEUR 601*	Developmental Neuroscience	2
NEUR 602*	Cellular Neuroscience	3
Elective*		3
		9
Semester 2		
NEUR 603*	Mammalian Neurobiology	3
NEUR 604*	Scientific Ethics	3
(OR)		
NEUR 702*	Research Methods	3
Elective*		3
		9
Semester 3		
NEUR 709*	NEUROSCIENCE@GMU	1
STATS*		3
Elective		2
		6
Semester 4		
BIOL 799*	Thesis	6