



February 27, 2018

Dear Colleagues,

The attached 2020 Checksheet for Nanomedicine represents the establishment of a new major in the Bachelor of Science in Nanoscience degree program. Nanomedicine refers to the use of nanomaterials and nanodevices in therapeutic and diagnostic applications. An example of the power of nanomedicine is the FDA-approved (2005) chemotherapy drug Abraxane, which consists of paclitaxel bound to nanoparticles of the protein albumin. These nanoparticles are too large to enter normal cells but able to infiltrate tumor cells. There are multiple compelling reasons for the creation of this new major, which include: 1) interest in the Nanoscience degree by two very distinct groups of students who are not well-served by a single major, 2) a distinct set of skills and knowledge required for students focused on nanomedicine compared to those who are focused more on the physical sciences aspects of nanoscience, 3) a growing recognition in the academic and research communities of nanomedicine as a distinct and thriving field, and 4) an increasing number of job opportunities in the area of nanomedicine. We firmly believe that creation of the Nanomedicine major will meet employer and student demand as well as position Virginia Tech as a leader in an increasingly important area with significant implications for a healthy population.

The Nanoscience degree program currently has approximately 90 students. We have identified two very distinct groups of students among this cohort and the students who have already graduated from the program. One group has a primary interest in the physical sciences aspects of the field, while the other (between one-third and half of the students) are much more interested in the life sciences aspects and implications of nanoscience. These two groups of students tend to have different skill sets with the physical sciences students having stronger mathematical skills and the life sciences students having stronger conceptual and visualization skills. This has led to a tension in a few key aspects of the curriculum, which first occurs in the NANO 2024 -Quantum Physics of Nanostructures course. The life sciences students struggle with the mathematics of this course, while the physical sciences students often would like to have delved deeper. This same trend happens in the NANO 3015-3016 - Synthesis, Fabrication, and Characterization of Nanostructures course and the NANO 4124 - Advanced Nanomaterials and Devices course. On the other hand, the NANO 4314 Nanomedicine course has needed to be taught with more direct inclusion of life sciences principles that are trivial to the life sciences

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students but difficult for the physical sciences students to keep up with. As a result, the single Nanoscience major does not serve either of these student populations as well as it could.

The creation of the Nanomedicine major will allow the two sets of students to share an essential, central core of nanoscience and then divert into sets of courses that provide them the desired depth for their specialization. The 2020 Checksheet utilizes existing courses to provide these separate paths for the students. For example, the Nanomedicine students will not be required to take NANO 4124 or MATH 1114 and 2214. Instead, they will take nine credits from a suite of biomedical-related courses offered throughout the university. In addition, the Nanomedicine students will take the life sciences versions of introductory physics and calculus. The Nanomedicine students will also take introductory biology, which is not required of the Nanoscience majors. We are in the process of developing two additional Nanoscience courses that will further address the separate needs of the Nanoscience and Nanomedicine majors. The first is a separate quantum physics for nanomedicine course that will be less quantitative and more conceptual, thereby also allowing the NANO 2024 - Quantum Physics of Nanostructures to become more mathematical. The second new course will create a nanomedicine sequence. The first semester will be required of both Nanomedicine and Nanoscience majors while the second will be required only of Nanomedicine majors and will rely deeply on a prior understanding of key life sciences concepts. Similarly, the Nanomedicine majors at that point will take NANO 3015 but not NANO 3016. NANO 3016 will then evolve into a more mathematical and quantum physics-based course that better serves the Nanoscience majors. These new courses will be established for inclusion in future checksheets.

The importance of nanomedicine as a separate field is made clear in several ways. At universities, Johns Hopkins University has a Nanobiotechnology graduate training program, Boston University offers an M.S. in Biomedical Engineering with a focus in Nanomedicine, University of Illinois Urbana-Champaign offers a Cancer Nanotechnology concentration, University of South Florida offers an M.S. in Pharmaceutical Nanotechnology, Northeastern University offers a graduate certificate in Nanomedicine, and Radiological Technologies University VT offers an M.S. in Nanomedicine. Johns Hopkins also has an Institute for Nanobiotechnology and the Johns Hopkins School of Medicine has a Center for Nanomedicine, both of which were visited by students in our Nanomedicine course this past fall. University of California at Santa Barbara has a Center for Nanomedicine. University of California at San Diego has a Center for Excellence in Nanomedicine and Engineering. The David Geffen School of Medicine at UCLA has a Division of Nanomedicine. The University of Utah has the Utah Center for Nanomedicine. Rose-Hulman Institute of Technology has Center for Nanomedicine. Conferences in the field of nanomedicine in 2018 include the International Conference and Exhibition on Nanomedicine and Nanotechnology in Healthcare (Auckland), the International Conference on Nanomedicine and Nanobiotechnology (Rome), the International Conference and

Exhibition on Nanomedicine and Drug Delivery (Tokyo), and the International Conference and Exhibition on Nanomedicine and Pharmaceutical Technology (Amsterdam). Regarding employment, Indeed and LinkedIn have job categories for nanomedicine with 36 and 25 listings, respectively as of this writing (2-28-18). This does not include the many jobs for which a Nanomedicine major would be well-trained that do not explicitly mention nanomedicine in the listing.

There is no Nanomedicine major at any university in the United States, which gives Virginia Tech a unique opportunity to be an educational leader in a rapidly growing frontier area. We anticipate that 20-40 students (freshman and sophomores) will declare the Nanomedicine major as soon as it becomes available. Given the large interest in life sciences areas by university applicants, we expect that within a few years the Nanomedicine major will have at least 30 entering students each year and will lead to a growth of the Nanoscience degree program to at least 50 students per year. The College of Science is not requesting additional university resources to deliver the Nanomedicine major. We would like to have the major available for enrollment in Fall 2018 with the first group of students to graduate with the Nanomedicine major in 2020.

Sincerely,



James R Heflin  
Professor of Physics  
Associate Dean for Research and Graduate Studies - College of Science  
Leader, Division of Nanoscience - Academy of Integrated Science

**College of Science**  
**Bachelor of Science in NANOSCIENCE**  
**Major in NANOMEDICINE**  
**For students graduating in calendar year 2020**

**I. Curriculum for Liberal Education (38 credit hours)**

*All courses used for the Curriculum for Liberal Education must be on the University's approved list.*

**Area 1 - Writing and Discourse (6 credit hours)**

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**Area 2 - Ideas, Cultural Traditions, and Values (6 credit hours)**

\_\_\_\_\_ 3\_\_ \_\_\_\_\_ 3\_\_

**Area 3 - Society and Human Behavior (6 credit hours)**

\_\_\_\_\_ 3\_\_ \_\_\_\_\_ 3\_\_

**Area 4 - Scientific Reasoning and Discovery (8 credit hours)**

PHYS 2205 General Physics*	3__	PHYS 2206 General Physics*	3__
PHYS 2215 General Physics Laboratory*	1__	PHYS 2216 General Physics Laboratory*	1__

**Area 5 - Quantitative and Symbolic Reasoning (6 credit hours)**

MATH 1025 Elementary Calculus*	3__	MATH 1026 Elementary Calculus*	3__
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**Area 6 - Creativity and Aesthetic Experience (3 credit hours)**

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**Area 7 - Critical Issues in a Global Context (3 credit hours)**

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**II. Nanoscience Degree Core Requirements (35 credit hours)**

FALL#	SPRING#
NANO 1015 Introduction to Nanoscience*	3__
NANO 2114 Nanoscience Research Seminar*	1__
NANO 3015 Nanoscale Synthesis, Fabrication, and Characterization*	4__
NANO 3114 Professional Dissemination of Nanoscience Research*	1__
NANO 4314 Nanomedicine*	4__
NANO 4994 Undergraduate Research*^	8__
NANO 1016 Introduction to Nanoscience*	3__
NANO 2024 Quantum Physics of Nanostructures*	4__
NANO 3016 Nanoscale Synthesis, Fabrication, and Characterization*	4__
NANO 3124 Nanoscience and the Environment*	3__

**III. Nanomedicine Major Requirements (26 credit hours)**

FALL#	SPRING#
CHEM 1035 General Chemistry*	3__
CHEM 1045 General Chemistry Lab*	1__
CHEM 2535 Organic Chemistry	3__
CHEM 2545 Organic Chemistry Lab	1__
BIOL 1105 Principles of Biology*	3__
BIOL 1115 Principles of Biology Laboratory*	1__
BIOL 2124 Cell and Molecular Biology for Engineers <sup>oo</sup>	2__
CHEM 1036 General Chemistry*	3__
CHEM 1046 General Chemistry Lab*	1__
CHEM 2536 Organic Chemistry	3__
CHEM 2546 Organic Chemistry Lab	1__
BIOL 1106 Principles of Biology*	3__
BIOL 1116 Principles of Biology Laboratory*	1__

**IV. Restricted Electives (9 credit hours):***Pick 3 of the following courses.*

BCHM 3114 Biochemistry for Biotechnology & the Life Sciences*	3__	BCHM/BIOL 4784 Applications in Molecular Life Science*	3__
BIOL 3404 Introductory Animal Physiology**	3__	BIOL 3774 Molecular Biology**	3__
BIOL 4664 Virology**	3__	BIOL 4674 Pathogenic Bacteriology**	3__
BIOL 4704 Immunology**	3__	BIOL 4874 Cancer Biology**	3__
BIOL 4884 Cell Biology**	3__	CHEM 4514 Green Chemistry*	3__
CHEM 4554 Drug Chemistry*	3__	NEUR 2025 Introduction to Neuroscience*	3__
NEUR 2026 Introduction to Neuroscience*	3__	NEUR 3914 Neuroscience of Drug Addiction*	3__
NEUR 4034 Diseases of the Nervous System*	3__	SYSB 2026 Introduction to Systems Biology*	3__
SYSB 3035 Systems Biology of Genes & Proteins*	4__	SYSB 3036 Systems Biology of Genes & Proteins*	4__
SYSB 3115 Network Dynamics & Cell Physiology*	4__	SYSB 3116 Network Dynamics & Cell Physiology*	4__

**V. Free Electives (12 credit hours)**

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**Prerequisites**

Some courses on this checksheet have prerequisites. Students are required to double check course prerequisites and equivalents. Please see your advisor or consult the Undergraduate Course Catalog for more information.

**Acceptable Substitutions**

BIOL 2124: BIOL 2104 Cell & Molecular Biology OR BIOL 2134 Cell Function Differentiation OR  
NEUR 3044 Cell Molecular Neuroscience

CHEM 1035/1036: CHEM 1055/1056 General Chemistry for Majors

CHEM 1045/1046: CHEM 1065/1066 General Chemistry Lab for Majors

CHEM 2535/2536: CHEM 2565/2566 Principles of Organic Chemistry

CHEM 2545/2546: CHEM 2555/2556 Organic Synthesis & Techniques Lab

MATH 1025/1026: MATH 1225/1226 Calculus of a Single Variable

NANO 2024: PHYS 3324 Modern Physics

PHYS 2205/2215: PHYS 2305 Foundations of Physics I

PHYS 2206/2216: PHYS 2306 Foundations of Physics I

BIOL 1105/1115 CHEM 1035/1045/1036/1046, MATH 1025/1026, PHYS 2305/2306:

ISC 1105/1115, 1106/1116, 2105/2115, 2106/2116 Integrated Science I-II and Integrated Science Lab I-II

**College of Science Foreign Language Requirement**

The requirement may be fulfilled by successful completion of one of the following:

1. The third year (level III) of one foreign language in high school.
2. The second year (level II) of one foreign language and the second year (level II) of a second foreign language in high school.
3. The equivalent of an 1106 foreign language at an accredited university or community college.
  - a. Note: A student who has not completed two (2) units of a single foreign language in high school must earn six (6) semester hours of college level credit in a foreign language (i.e., both 1105 and 1106). These six hours are in addition to the 120 hours required for graduation.
4. Credit by examination for a foreign language. The credit by exam option is available only to student who have gained knowledge of a foreign language without the benefit for formal training.

Students whose native language is not English may be exempted from the foreign language through demonstrating satisfactory knowledge of the foreign language as prescribed by the Department of Foreign Languages. (No credit is granted).

### **Satisfactory Progress Towards Degree**

Upon having attempted 72 credit hours, the student will have completed NANO 1015-1016, MATH 1025-1026, CHEM 1035-1036, CHEM 1045-1046, PHYS 2205-2206, PHYS 2215-2216, BIOL 1105, BIOL 1106, BIOL 1115, & BIOL 1116

### **Graduation Requirements**

120 credit hours are required for graduation. These credits must include the courses required for the major (see above sections). To graduate, a student must have at least a 2.0 in-major GPA and overall GPA.

\* ***In Major GPA:*** Courses marked with \* will be used for computing the "in major" GPA.

# ***Fall/Spring Course Offerings:*** Please consult with your advisor to ensure the courses are offered in the semester you intend to take them.

^ ***Undergraduate Research:*** All 8 credits are not taken in one semester. They are often split among different semesters.

∞ ***BIOL 2124*** is not an accepted prerequisite for BIOL courses that require BIOL 2134. Students wishing to take BIOL courses from the restricted electives list should take BIOL 2134. Please consult your advisor as to which course is right for you.