Resolution to Approve B.S. in Microbiology

Documents included:

1. Resolution to Approve a B.S. in Microbiology
2. B.S. in Microbiology Degree Proposal
3. Dean Lay Nam Chang – Introductory Presentation
4. Professors Stevens and Popham – Degree Presentation

RESOLUTION TO APPROVE THE BACHELOR OF SCIENCE DEGREE IN MICROBIOLOGY

WHEREAS, Microbiology, a Science, Technology, Engineering, Mathematics, and Health (STEM-) discipline, is the study of the most abundant and pervasive organisms on earth, which play important roles in every biome and in most aspects of human health and industry; and

WHEREAS, microbiology is integral to the prevention and cure of human and animal infectious disease, to the improvement of agricultural yields, to the preservation of food products, to the elimination of waste products and protection of the environment, to the understanding and manipulation of global elemental cycles, and to the development of biofuels; and

WHEREAS, the Department of Biological Sciences is in an excellent position to initiate a bachelor of science in microbiology, due to its strong base of senior faculty who are actively engaged in microbiology research and the broad microbiology option curriculum currently offered to students in this field; and

WHEREAS, the bachelor of science in microbiology will provide students with the base of knowledge in the theoretical aspects and experimental tools and techniques in microbiology, and

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

WHEREAS, the undergraduate degree in microbiology is unique in the Commonwealth of Virginia and will establish Virginia Tech and the Commonwealth as leaders in education in this field that affects all areas of human endeavor;

NOW, THERFORE BE IT RESOLVED, that the bachelor of science degree in microbiology be approved effective spring 2015 and the proposal forwarded the State Council of Higher Education for Virginia (SCHEV) for approval, and to the Southern Association of Colleges and Schools – Commission on Colleges (SACS-COC) for notification.

RECOMMENDATION:

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

March 24, 2014

Virginia Tech Degree Proposal
Bachelor of Science in Microbiology
(CIP: 26.0502)

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

Program description

The Department of Biological Sciences in the College of Science at Virginia Tech is proposing a new Bachelor of Science (B.S.) degree in Microbiology to be implemented in Spring 2015. Virginia Tech is in a unique position to immediately provide the necessary curriculum for a Microbiology major/degree.

Knowledge and research in microbiology is critical to myriad aspects of our everyday life, with particular impacts on human health, industry and technology, and our interactions with our environment. Due to the presence and participation of microbes in virtually every environment, biological process, and ecological structure, individuals with advanced microbiology knowledge are recruited into the broadest range of health, industrial, and environmental activities. Microbes play key roles in both deterioration and maintenance of human and animal health, in the preservation and degradation of food, in the generation of biofuels, and in maintenance of the earth's environment and climate. Individuals with a B.S. in Microbiology are prepared to enter the job markets associated with all of these issues and to enter professional and graduate schools.

Peer institutions in several other states have offered a B.S. in Microbiology for many years, and these programs have been highly successful in attracting students and producing successful graduates. Virginia Tech is the *only* institution of higher learning in the Commonwealth of Virginia that currently has an undergraduate Microbiology option. Any other institution would require significant resources and curriculum development in order to produce a comparable program. We are now proposing conversion of the Microbiology option to a formal degree in Microbiology. This change will:

- increase the visibility of the curriculum to potential students and their parents and thereby enhance recruitment of students interested in STEM and STEM-H.
- enable potential employers to understand the significant level of specialized training received by students in this program; many employers do not fully understand the significance of an "option" and ask for a degree in microbiology in employment ads. Creation of a degree in Microbiology will promote and enhance university-industry collaboration.
- permit formal recognition of specialized coursework on the diploma rather than only on the transcript, which is a point of confusion and angst to students and parents.

Curriculum summary

The B.S. Microbiology curriculum comprises 120 credits, including all requirements for the Curriculum for Liberal Education (38 credits), entry-level science and math courses (28 credits), common core courses (28-29 credits), restrictive electives (9-12 credits) and free electives (13-17 credits).

Entry-level science and math courses include Biology Orientation Seminar, General Chemistry lectures and labs, Organic Chemistry lectures and lab, General Physics lectures and labs, and Biological Statistics.

Common core courses include General Microbiology and its associated laboratory which serve as the gateway courses into the major with students coming from the new General Biosciences entry program, the traditional Biological Sciences major or University Studies programs, or transfer students from other institutes. Upon successful completion of General Microbiology and its laboratory with a grade of C or better students will be permitted to begin taking upper-level courses in microbiology. Two other sophomore-level courses will be required, Cell & Molecular Biology and Genetics, which will provide additional preparatory background education. All majors will be required to take Microbial Genetics, Microbial Physiology, and Biochemistry for Biotechnology in which they will learn many of the essential concepts of the curriculum. The students will then take either Microbial Molecular Genetics & Physiology Lab or Molecular Biology and its associated lab so that they begin to develop more advanced laboratory skills. To gain training in human-health relevant topics students will be required to take either Pathogenic Bacteriology and its lab or Immunology and its lab. Students will also be required to take Microbiology Senior Seminar to get career-advancement training separate from their individual academic advising.

Restricted elective courses will be selected by students from a list, two of which must have a laboratory experience. Thus by the time they complete the Microbiology degree, students will have completed five required upper-level laboratory courses giving them a marketable skill set and practice in analyzing their experimental data and presenting it in oral and written media. Working with their academic advisors, they will customize their degree program to prepare them for their specific career objectives by enabling them to focus on sub-discipline areas within the broader field of microbiology. A summary of the curriculum follows:

- Curriculum for Liberal Education requirements (38 credits):
  - Area I: Writing and Discourse (6 credits)
    - ENGL 1105 First-Year Writing (3)
    - ENGL 1106 First-Year Writing (3)
  - Area II: Ideas, Cultural Traditions and Values (6 credits)
  - Area III: Society and Human Behavior (6 credits)
  - Area IV: Scientific Reasoning and Discovery (8 credits-completed with Microbiology degree)
    - BIOL 1105 Principles of Biology (3)
    - BIOL 1115 Biological Principles Lab (1)
    - BIOL 1106 Principles of Biology (3)
    - BIOL 1116 Biological Principles Lab (1)
  - Area V: Quantitative and Symbolic Reasoning (6 credits-completed with Microbiology degree)
    - MATH 1016 Elem Calculus w/Trig (3)
    - MATH 2015 Elem Calculus w/Trig (3)

Area VI: Creativity and Aesthetic Experience (3 credits)
Area VII: Critical Issues in a Global Context (3 credits)

- Core Science and Math requirements (28 credits)
  - BIOL 1004 Biology Orientation Seminar (1)
  - CHEM 1035 General Chemistry (3)
  - CHEM 1045 General Chemistry Lab (1)
  - CHEM 1036 General Chemistry (3)
  - CHEM 1046 General Chemistry Lab (1)
  - CHEM 2535 Organic Chemistry (3)
  - CHEM 2545 Organic Chemistry Lab (1)
  - CHEM 2536 Organic Chemistry (3)
  - CHEM 2546 Organic Chemistry Lab (1)
  - PHYS 2205 General Physics (3)
  - PHYS 2215 General Physics Lab (1)
  - PHYS 2206 General Physics (3)
  - PHYS 2216 General Physics Lab (1)
  - STAT 3615 Biological Statistics (3)

- Core Microbiology requirements (28-29 credits):
  - BIOL 2604 General Microbiology (3)
  - BIOL 2614 General Microbiology Lab (1)
  - BIOL 2004 Genetics (3)
  - BIOL 2104 Cell & Molecular Biology (3)
  - BIOL 4624 Microbial Genetics (3)
  - BIOL 4634 Microbial Physiology (3)
  - BCHM 3114 Biochemistry for Biotechnology (3)
  - BIOL 4764 Microbiology Senior Seminar (2)

  - BIOL 4644 Microbial Molecular Genetics and Physiology Lab (3)
  - **OR**
  - BIOL 3774 Molecular Biology (3) and BIOL 3104 Cell & Molecular Biol. Lab (1)

  - BIOL 4674 Pathogenic Bacteriology (3) and BIOL 4724 Pathogenic Bacteriol. Lab (1)
  - **OR**
  - BIOL 4704 Immunology (3) and BIOL 4714 Immunology Lab (1)

- Restricted elective courses (9-12 credits):
  - **Three** of the following (**two** must include lab):
    - BIOL/CEE/CSES/ENSC 4164 Environmental Microbiology (includes lab) (3)
    - BIOL 3454 Introductory Parasitology (includes lab) (4)
    - BIOL 4075 Bioinformatics Methods (includes lab) (3)
    - BIOL/FST 4604 Food Microbiology (includes lab) (4)
    - BIOL 4644 Microbial Molecular Genetics and Physiology Lab (3) (if not taken above)
    - BIOL 4664 Virology (3)

BIOL 4674 Pathogenic Bacteriology (3) with or without BIOL 4724 Pathogenic Bacteriol. Lab (1) (if not taken above)
BIOL 4704 Immunology (3) with or without BIOL 4714 Immunology Lab (1) (if not taken above)
BIOL 4734 Inflammation Biology (3)
BIOL 4804 Prokaryotic Diversity (3)
BIOL 4xxx Research Methods in Molecular Biology (includes lab) (3)
BIOL 4994 Undergraduate Research (includes lab) (total 4 credits over two semesters)
FST 4634 Epidemiology of Foodborne and Waterborne Diseases
PPWS 4114 Microbe Forensics/Biosecurity (3)

- Free Electives (13-17 credits):

Relevance to university mission and strategic planning

Virginia Tech is a public land-grant university serving the Commonwealth of Virginia, the nation, and the world community. The discovery and dissemination of new knowledge are central to its mission. Through its focus on teaching and learning, research and discovery, and outreach and engagement, the university creates, conveys, and applies knowledge to expand personal growth and opportunity, advance social and community development, foster economic competitiveness, and improve the quality of life. The proposed B.S. in Microbiology degree supports this internal vision for higher education by creating a signature educational experience at Virginia Tech. A Microbiology degree will provide relevant and significant training for students to enter a range of STEM and STEM-H careers, either directly following graduation or ultimately following further education. The laboratory-rich, hands-on experiences that Microbiology degree students receive will make them attractive to employers in Virginia and elsewhere.

Justification for the proposed program

Driven by human health issues such as re-emerging and newly emerging infectious agents and demand for renewable resources to create global sustainability, the field of microbiology is again in the spotlight.

> "The need for qualified microbiologists continues to grow, both for basic research and practical applications. Many microbes have yet to be discovered. In addition, microbiologists are still studying how the known microbes function. As a result, the field of microbiology has virtually unlimited potential. Microbiologists are needed across many industries, including in academic, technology, industrial and environmental organizations" (http://microbes.org/microbiology-careers).

The importance of training in microbiology is reflected directly in the role of microbes in virtually all areas of the human experience. To put it simply, microbes are present and active in every environment we deal with, from forests, lakes, and farms to the relative "sterility" of a hospital ward and the complex microbiome that is within our own intestinal tract. Despite the fact that they are mostly invisible to simple human observation, microbes are the most abundant life forms on earth in terms of species diversity as well as total

mass. Our understanding of microbes contributes to almost all fields of scientific and technological endeavor.

Recent research trends in the biological sciences have increasingly and properly required collaborative efforts across multiple fields such as microbiology, molecular biology, environmental sciences, ecology, and computational biology. Broader interactions of biologists with engineers and physical scientists are key to utilizing biological systems to solve emerging technical challenges. The bellwether 2009 report from the National Academy of Sciences entitled *A New Biology for the 21st Century* states, "The New Biology depends on interdisciplinary collaborations among scientists and engineers who share sufficient common language and understanding to envision and embrace common goals." (http://www.nap.edu/openbook.php?record_id=12764&page=73)

Of particular relevance to this proposal is that the suggested solutions to ALL of these societal challenges are deeply rooted in the understanding and application of microbes and microbial-driven processes. Microbiologists are critical in providing the detailed knowledge of microbial populations and capabilities to move technological solutions forward. Undergraduate students with basic microbiology training will have myriad opportunities to enter into developing fields of great importance for Virginia, the United States, and the entire world population.

A major factor in current and future technological advances will be our ability to understand the genetic basis of microbial processes. The *New Biology* report says, "Harnessing the molecular biology and biochemistry of microbes, either in pure culture under laboratory conditions or in naturally occurring complex communities, promises to contribute significantly to addressing all four challenges presented in this report. Microbial communities support the growth of plants, affect human health, are critical components of all ecosystems, and can be engineered to produce fuels." (http://www.nap.edu/openbook.php?record_id=12764&page=50).

With regard to **food production**, the *New Biology* report discusses the importance of microbes in the cultivation of food crops. "Furthermore, complex microbial communities in the soil, previously difficult to study, play critical roles in providing nutrients and protecting plants from pests and diseases. Understanding these microbial communities in predictive detail will also point to new ways to increase plant productivity." (http://www.nap.edu/openbook.php?record_id=12764&page=24).

With regard to the **environment**, the *New Biology* report states, "microbes have a fundamental impact on the biogeochemical cycles of the planet and on the health of all its inhabitants" (http://www.nap.edu/openbook.php?record_id=12764&page=49). They are responsible for the majority of the flux of the elemental cycles on earth (eg: carbon and nitrogen cycles). Some steps in these cycles, such as nitrogen fixation, are ONLY carried out naturally by microbes, and they do these things using only renewable energy resources.

With regard to **energy**, the *New Biology* report discusses the importance of microbes in the generation of biofuels (http://www.nap.edu/openbook.php?record_id=12764&page=31). They say, "efforts to discover, characterize, and engineer microbes so that they serve as factories for high production rates, with efforts to engineer production systems that maximize those microbes' productivity… will allow next-generation biofuels to compete with gasoline at prevailing prices," and "An integrated approach that includes scientists and engineers expert at each step is

essential. The combined efforts of plant scientists, microbiologists, ecologists, chemical and industrial process engineers, molecular biologists, geneticists, and many others are needed to develop and optimize the biomass-to-biofuel system."

With regard to **human health**, the *New Biology* report discusses the importance of microbes in human health (http://www.nap.edu/openbook.php?record_id=12764&page=33). "Humans are intimately associated with a complex microbial community—the microbiome. Rapidly accumulating discoveries of the many essential roles of this microbial consortium are redefining our understanding of human health and making it clear that a true understanding of human health must take into account not only the human genome, but also the genomes of each human's microbial community. Understanding the role of microbes and viruses in human health is a major challenge, but it also holds the promise of providing new intervention points for prevention, diagnosis, and treatment of disease."

To become a microbiologist, a person needs to complete a bachelor's degree program in microbiology**.** These programs introduce students to concepts in bioinformatics, virology and immunology. Microbiology students also take laboratory courses to see first hand how microorganisms react to different stimuli and behave in different environments. A goal of the proposed Microbiology degree program is to provide undergraduate students not only with specialized knowledge of microbes, but also with the broad training required to form productive interactions within collaborative groups. The available coursework in environmental systems, host-pathogen interactions, bioinformatics, and epidemiology are examples of this breadth.

Currently the state of Virginia does not have an institute of higher learning that offers a B.S. degree in Microbiology. Now is the time to provide this degree opportunity to our citizens and provide qualified employees to our businesses and advanced students for professional programs.

Student Demand

Over the past three years (2011-2013) since Microbiology option students have specifically been tracked, an average of 30 students per year have completed the Microbiology Option within the Biological Sciences degree. It is expected that all of these students would enter a new Microbiology degree. The increased visibility of a Microbiology degree program is expected to draw additional student enrollment, including in-state students that might otherwise choose an out-of-state institution that offers a Microbiology degree and out-of-state students specifically attracted to this degree program.

Moreover, a summary of enrollment numbers in microbiology-related courses for the past three years is presented in the table below. Enrollment in General Microbiology (BIOL 2604) is always large and represents students from a variety of Virginia Tech colleges and majors. Students expected to enroll in the Microbiology degree are those that continue into the required advanced core courses of the degree, BIOL 4624 and BIOL 4634.

Annual Enrollments in Virginia Tech Core Microbiology Courses

	Annual Enrollment		
Course	**2010-2011**	**2011-2012**	**2012-2013**
BIOL 2604: General Microbiology	747	929	>903
BIOL 4624: Microbial Genetics	48	81	58
BIOL 4634: Microbial Physiology	59	61	63
BIOL 4674: Pathogenic Bacteriology	107	114	116
BIOL 4724: Pathogenic Bacteriology Lab	95	95	75
BIOL 4704: Immunology	106	105	103

Given this consistent interest, we predict an ongoing enrollment of 120 students in this degree program, with 30 graduates/year.

Employment Demand

Graduates from the Microbiology degree program will be qualified for technical laboratory positions in a wide variety of industries. These include the production of pharmaceuticals; fermented food products; microbial and enzymatic additives for industrial, agricultural, and consumer markets; and the conversion of potential fuel sources to readily useable energy. Microbiology technicians are employed for monitoring safety in food production, water purification, wastewater treatment, and clinical settings. Several emerging industries are highly dependent on microbiological expertise, and employment in these fields will be growing.

The U.S. Bureau of Labor Statistics expects a 13% increase in the number of jobs for microbiologists and a 14% increase in the number of jobs for biological technicians between 2010 and 2020, which is about the average for all jobs. New positions will appear in the pharmaceutical and environmental industries, in alternative energy and in agriculture. Microbiologists who understand both microbiology and related fields will have the best job opportunities (http://work.chron.com/need-become-microbiologist-7907.html). Graduates may work in the pharmaceutical, agricultural or food production industries (http://education-portal.com/articles/Microbiologist_Educational_Requirements_for_a_Career_in_Microbiology.html).

Resource Needs/Savings

All required and elective courses are already in place as part of the Microbiology option. Required core science and math courses are large introductory courses taught by full and part time faculty in several departments. As the majority of Microbiology majors will be derived from current Biological Sciences majors, the program will not impart a significant additional load on any of these courses.

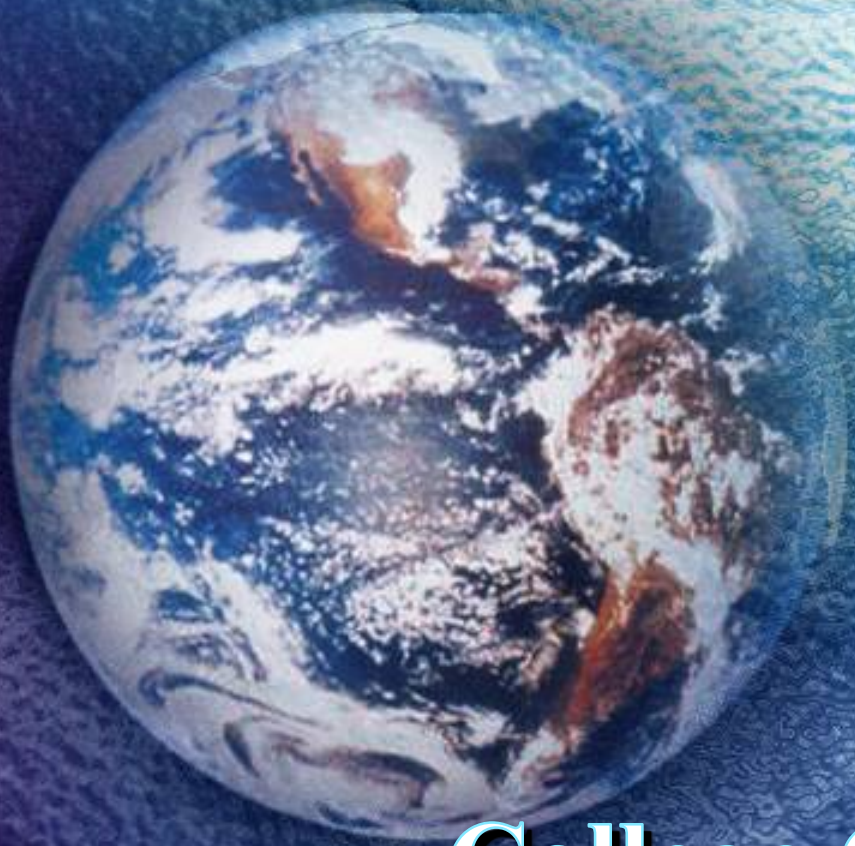
Required core microbiology courses are taught by full-time faculty and part-time instructors in the Biological Sciences department and one full-time faculty member in Biochemistry. Support for many of the microbiology laboratory classes are provided by two full-time classified staff members in the department of Biological Sciences. For courses in the Microbiology curriculum, faculty replacements will be needed in Biological Sciences and other departments as individuals teaching key classes retire. If enrollment numbers increase dramatically, then additional faculty and graduate teaching assistants may be needed to teach classes (e.g., Pathogenic Bacteriology & lab and Immunology & lab) popular not just with Microbiology students, but with other life sciences majors as well. New Biological Sciences hires in the areas of Environmental Microbiology and Eukaryotic Microbiology would broaden the elective options available to students, as well as provide additional mentors for students interested in undergraduate research. These types of faculty hires are within the Biological Sciences 5-year hiring plan currently under development. Continued College and University support for growth of the Biological Sciences tenure track faculty number towards a total of 50 will allow implementation of these plans.

In addition to faculty resources, it is critical that facilities and staff for laboratory instruction be maintained, and that implementation of lab fees continue so that students can receive extensive, state-of-the-art training in microbiology methods and technology.

RESOURCE	ESTIMATED COSTS (use NA if not applicable)
Faculty	NA
Administrative Staff	NA
Graduate Teaching/ Graduate Research Assistants	NA
Space	NA
Library	NA
Equipment	NA
Other	NA

Attachment B

VirginiaTech



College Of Science: Our Vision

Lay Nam Chang, Dean

Virginia Tech Board of Visitors

March 24, 2014

The College of Science

- College of Science is Virginia Tech's leader for meeting the nation's Science, Technology, Engineering, Mathematics, and Health (STEM-H) challenges
- Eight key departments reside in *Science: Biological Sciences, Chemistry, Economics, Geosciences, Mathematics, Physics, Psychology, and Statistics*
- We already provide much of the basic training, but rapid science evolution means goals and methodology need changing

Three Degree Proposals

Programs to emphasize teamwork, cognitive thinking, and interdisciplinarity:

- Microbiology - *Biological Sciences*
- Nanoscience – *Biological Sciences, Chemistry, Geosciences, Physics and others*
- Computational Modeling and Data Analytics (CMDA) – *Computer Science (College of Engineering), Mathematics, Statistics*

B.S. in Microbiology in the Dept. of Biological Sciences Virginia Tech

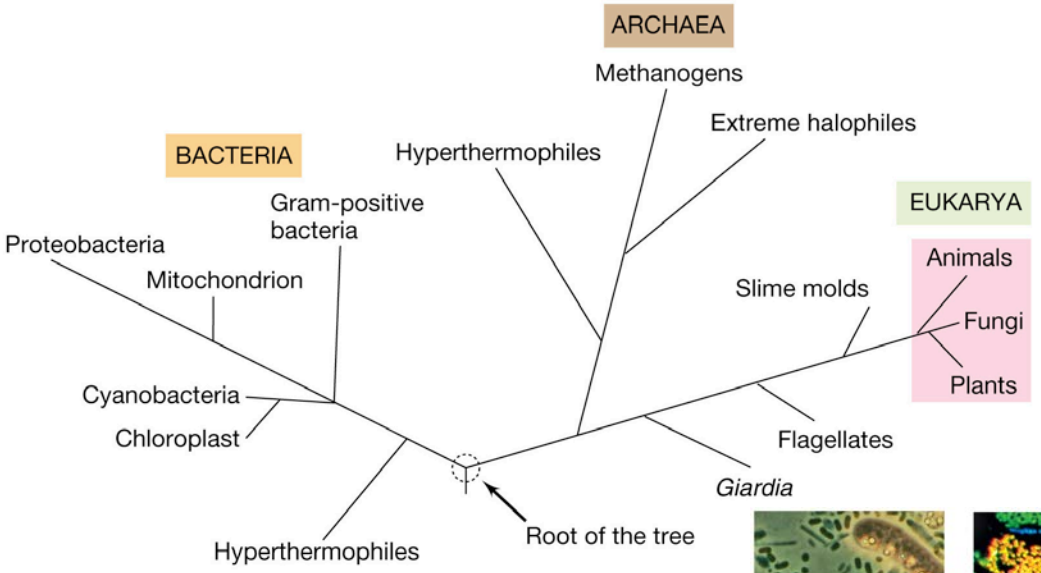
Dr. Ann M. Stevens

Dr. David L. Popham

BOV Meeting 3/24/14

Why are microbes important?

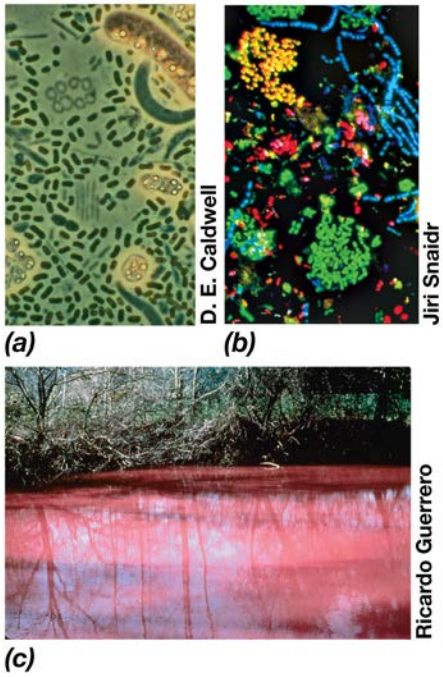
-Most numerous and diverse organisms on the planet



-Public health and safety; Emerging diseases

-Global sustainability and environmental conservation

-Model systems



B.S. in Microbiology Curriculum

Conversion of the current Microbiology Option managed under the B.S. in Biological Sciences

Cross campus cooperation:

-Biological Sciences faculty teach core/required courses

-College of Agriculture and Life Sciences and VetMed faculty contribute some elective courses

Existing student demand: ~35 graduates per year in micro option

~120 projected annual enrollment

Cost: No new resources needed

Impact:

-The only B.S. Microbiology major/degree in Virginia

-New STEM-H degree (Governor's initiative)

-Enhanced visibility of program; Improved recruiting

B.S. in Microbiology-Career Paths

- A course curriculum designed to prepare students for:
  - Careers in Biotech industry
  - Graduate school in Micro/Immuno
- Also popular with students interested in:
  - Medical careers
    - Med/Dental/Vet/Pharm school
    - Master of Public Health/Epidemiology
    - Clinical laboratory science
  - Food safety/production
  - Forensics
  - Environmental sciences

Broad support from Virginia-based and regional biotechnology companies/organizations!

Attachment B

- Altria, Richmond
- American Biosystems Inc., Roanoke
- American Type Culture Collection, Manassas
- Dupont, Wilmington, Delaware
- Engineered Biopharmaceuticals, Danville
- Indoor Biotech, Charlottesville
- Jefferson College of Health Sciences, Roanoke
- Mediatech Corning, Manassas
- Novozymes, Salem
- Tech Lab, Blacksburg
- Techulon Blacksburg
- United States Dept. of the Navy, Dahlgren
- Virginia-BIO, statewide organization