UNIVERSITY OF DELAWARE

MASTER'S PROGRAM IN BIOINFORMATICS & COMPUTATIONAL BIOLOGY

ACADEMIC PROGRAM APPLICATION

NOVEMBER 22, 2009

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PART I

UNIVERSITY FACULTY SENATE FORM

MASTER OF SCIENCES IN BIOINFORMATICS & COMPUTATIONAL BIOLOGY: COMPUTATIONAL SCIENCES CONCENTRATION

Academic Program Approval

This form is a routing document for the approval of new and revised academic programs. Proposing department should complete this form. For more information, call the Faculty Senate Office at 831-2921.

Submitted by: _____Cathy H. Wu_____ phone number ____831-8869_____

Department: _____Computer & Information Sciences____ email address __wuc@udel.edu__

Action: _Request for New Master of Science in Bioinformatics & Computational Biology____
_____(BICB-MS), Computational Sciences Concentration (CS)_____
(Example: add   major/minor/concentration,   delete   major/minor/concentration,   revise major/minor/concentration, academic unit name change, request for permanent status, policy change, etc.)

Effective term_____10F_____
(use format 04F, 05W)

Current degree _____N/A_____
(Example: BA, BACH, BACJ, HBA, EDD, MA, MBA, etc.)

Proposed change leads to the degree of: _____MS_____
(Example: BA, BACH, BACJ, HBA, EDD, MA, MBA, etc.)

Proposed name: __Master of Science in Bioinformatics & Computational Biology (BICB-MS),
_____Computational Sciences Concentration (CS)_____
Proposed new name for revised or new major / minor / concentration / academic unit
(if applicable)

Revising or Deleting:

    Undergraduate major / Concentration:_____
(Example: Applied Music – Instrumental degree BMAS)

    Undergraduate minor:_____
(Example: African Studies, Business Administration, English, Leadership, etc.)

    Graduate Program Policy statement change:_____
(**Must attach** your Graduate Program Policy Statement)

    Graduate Program of Study:_____
(Example: Animal Science: MS Animal Science: PHD Economics: MA Economics: PHD)

    Graduate minor / concentration:_____

Note: all graduate studies proposals must include an electronic copy of the Graduate Program Policy Document, highlighting the changes made to the original policy document.

List new courses required for the new or revised curriculum. How do they support the overall program objectives of the major/minor/concentrations)?
(Be aware that approval of the curriculum is dependent upon these courses successfully passing through the Course Challenge list. If there are no new courses enter "None")

CISC636: Bioinformatics (3) * submitted for re-title from "Introduction to Bioinformatics"
PLSC636: Plant Genes and Genomes (3) * submitted for re-title from "Advanced Plant Genetics"
MATH560: Introduction to Systems Biology (3) * adapted from MATH460
STAT613: Multivariate Statistical Methods with Biology Applications (3) * new course being developed
BINF869: Master's Thesis * new course listing
BINF865: Seminar * new course listing
STAT670: Introduction to Statistical Analysis I (3) * new course being developed
STAT671: Introduction to Statistical Analysis II (3) * new course being developed

Explain, when appropriate, how this new/revised curriculum supports the 10 goals of undergraduate education: http://www.ugs.udel.edu/gened/

    N/A

Identify other units affected by the proposed changes:
(Attach permission from the affected units. If no other unit is affected, enter "None")

    College of Arts & Sciences:
        Department of Biological Sciences
        Department of Mathematical Sciences
    College of Agriculture & Natural Resources
        Department of Plant & Soil Sciences
        Department of Food & Resource Economics
        Department of Animal & Food Sciences
    College of Engineering
        Department of Electrical & Computer Engineering
        Department of Chemical Engineering
    College of Earth, Ocean & Environment
        Marine Biosciences Program
    Alfred Lerner College of Business & Economics
        Department of Business Administration
    College of Education & Public Policy
        School of Urban Affairs & Public Policy

Describe the rationale for the proposed program change(s):
(Explain your reasons for creating, revising, or deleting the curriculum or program.)

The Master of Science in Bioinformatics & Computational Biology (BICB-MS) will provide an interdisciplinary program to foster research collaborations across Colleges, and will support the future development of a PhD degree program in Bioinformatics & Computational Systems Biology. The thesis-based BICB-MS degree will prepare students for advanced research. The

Computational Sciences Concentration (CS) will allow students with strong quantitative sciences background to gain solid knowledge and research experience in developing computational methods and bioinformatics tools and databases for the study of biological systems. The graduates may pursue further study towards a PhD or other professional degree, or a research career in academia, industry, or government agencies.

Program Requirements:
(Show the new or revised curriculum as it should appear in the Course Catalog. If this is a revision, be sure to indicate the changes being made to the current curriculum and **include a side-by-side comparison** of the credit distribution before and after the proposed change.)

BICB-MS Computational Sciences Concentration (CS) – Degree Requirement	
33 Credit Hours Total	
Bioinformatics & Computational Biology Core – Computational Sciences	15 Credits
Ethics Core	3 Credits
Electives – Computational Sciences	6 Credits
Thesis	6 Credits
Seminar	3 Credits (1 Credit/Semester, P/F)

BICB-MS Computational Sciences Concentration (CS) – Course Curriculum	
Bioinformatics & Computational Biology Core – Computational Sciences (15)	
Bioinformatics (3)	CISC636: Bioinformatics (3) *
Introduction to Discipline (3) [select one]	ELEG671: Introduction to Biomedical Engineering (3)
	BISC602: Molecular Biology of Animal Cells (3)
	BISC612: Advanced Cell Biology (3)
	BISC654: Biochemical Genetics (3)
	PLSC636: Plant Genes and Genomes (3) *
	ANFS670: Principles of Molecular Genetics (3)
	MAST616: Methods in Molecular Biology (3)
Systems Biology (3)	MATH560: Introduction to Systems Biology (3) *
Database (3)	CISC637: Database Systems (3)
Biostatistics (3) [select one]	STAT613: Multivariate Statistical Methods with Biology Applications (3) *
	STAT656: Biostatistics (3)
Ethics Core (3)	
Ethics (3) [select one]	BISC631: Practice of Science (3)
	UAPP648: Environmental Ethics (3)
	UAPP650: Values Ethics and Leadership (3)
	BUAD840: Ethical Issues in Global Business Environments (3)
Electives – Computational Sciences (6)	
Electives (6) [select two]	CISC841: Algorithms in Bioinformatics (3)
	CISC621: Algorithm Design and Analysis (3)
	CISC640: Computer Graphics (3)
	CISC642: Introduction to Computer Vision (3)
	CISC650: Computer Networks (3)
	CISC675: Object Oriented Software Engineering (3)
	CISC681: Artificial Intelligence (3)

	CISC683: Introduction to Data mining (3)
	CISC882: Natural Language Processing (3)
	CISC886: Multi-Agent Systems (3)
	CISC887: Internet Information Gathering (3)
	CISC888: Machine Learning (3)
	MATH607: Survey of Scientific Computing (3)
	MATH611: Introduction to Numerical Analysis and Scientific Computing (3)
	STAT670: Introduction to Statistical Analysis I (3) *
	STAT671: Introduction to Statistical Analysis II (3) *
	STAT608: Statistical Research Methods (3)
	STAT615: Design and Analysis of Experiments (3)
	STAT619: Time Series Analysis (3)
	STAT621: Survival analysis (3)
	STAT674: Applied Data Base Management (3)
	ELEG633: Image Processing (3)
	ELEG652: Principles of Parallel Computer Architectures (3)
	ELEG655: High-Performance Computing with Commodity Hardware (3)
	ELEG679: Introduction to Medical Imaging Systems (3)
	ELEG680: Immunology for Engineers (3)
	CHEG620: Biochemical Engineering (3)
	CHEG621: Metabolic Engineering (3)
Thesis (6)	
Thesis (6)	BINF869: Master's Thesis (1-6) *
Seminar (3)	
Seminar [3 semesters]	BINF865: Seminar (1) *

ROUTING AND AUTHORIZATION

(Please do not remove supporting documentation.)

Department Chairperson _____ Date_____

Dean of College_____ Date_____

Chairperson, College Curriculum Committee_____ Date_____

Chairperson, Senate Com. on UG or GR Studies_____ Date_____

Chairperson, Senate Coordinating Com._____ Date_____

Secretary, Faculty Senate_____ Date_____

Date of Senate Resolution_____ Date to be Effective_____

Registrar _____ Program Code_____ Date_____

Vice Provost for Academic Affairs & International Programs_____ Date_____

Provost _____ Date_____

Board of Trustee Notification _____ Date_____

Revised 10/23/2007 /khs

MASTER OF SCIENCES IN BIOINFORMATICS & COMPUTATIONAL BIOLOGY: LIFE SCIENCES CONCENTRATION

Academic Program Approval

This form is a routing document for the approval of new and revised academic programs. Proposing department should complete this form. For more information, call the Faculty Senate Office at 831-2921.

Submitted by: _____ Cathy H. Wu _____ phone number _____ 831-8869 _____

Department: _____ Computer & Information Sciences _____ email address _____ wuc@udel.edu _____

Action: Request for New Master of Science in Bioinformatics & Computational Biology (BICB-MS), Life Sciences Concentration (LSC)
      (Example: add major/minor/concentration, delete major/minor/concentration, revise major/minor/concentration, academic unit name change, request for permanent status, policy change, etc.)

Effective term _____ 10F _____
      (use format 04F, 05W)

Current degree _____ N/A _____
      (Example: BA, BACH, BACJ, HBA, EDD, MA, MBA, etc.)

Proposed change leads to the degree of: _____ MS _____
      (Example: BA, BACH, BACJ, HBA, EDD, MA, MBA, etc.)

Proposed name: Master of Science in Bioinformatics & Computational Biology (BICB-MS), Life Sciences Concentration (LSC)
      Proposed new name for revised or new major / minor / concentration / academic unit
      (if applicable)

Revising or Deleting:

    Undergraduate major / Concentration: _____
          (Example: Applied Music – Instrumental degree BMAS)

    Undergraduate minor: _____
          (Example: African Studies, Business Administration, English, Leadership, etc.)

    Graduate Program Policy statement change: _____
          (**Must attach** your Graduate Program Policy Statement)

    Graduate Program of Study: _____
          (Example: Animal Science: MS Animal Science: PHD Economics: MA Economics: PHD)

    Graduate minor / concentration: _____

Note: all graduate studies proposals must include an electronic copy of the Graduate Program Policy Document, highlighting the changes made to the original policy document.

List new courses required for the new or revised curriculum. How do they support the overall program objectives of the major/minor/concentrations)?
(Be aware that approval of the curriculum is dependent upon these courses successfully passing through the Course Challenge list. If there are no new courses enter "None")

MAST697: Bioinformatics Programming for Biologists (3) * submitted for permanent status
MAST698: Environmental and Systems Bioinformatics (3) * submitted for permanent status
STAT613: Multivariate Statistical Methods with Biology Applications (3) * new course being developed
BINF869: Master's Thesis * new course listing
BINF865: Seminar * new course listing
STAT670: Introduction to Statistical Analysis I (3) * new course being developed
STAT671: Introduction to Statistical Analysis II (3) * new course being developed
PLSC636: Plant Genes and Genomes (3) * submitted for re-title from "Advanced Plant Genetics"

Explain, when appropriate, how this new/revised curriculum supports the 10 goals of undergraduate education: http://www.ugs.udel.edu/gened/

       N/A

Identify other units affected by the proposed changes:
(Attach permission from the affected units. If no other unit is affected, enter "None")

       College of Arts & Sciences:
              Department of Biological Sciences
              Department of Chemistry & Biochemistry
       College of Agriculture & Natural Resources
              Department of Plant & Soil Sciences
              Department of Food & Resource Economics
              Department of Animal & Food Sciences
       College of Earth, Ocean & Environment
              Marine Biosciences Program
       College of Health Sciences
              Department of Health, Nutrition & Exercise Sciences
              Department of Physical Therapy
       Alfred Lerner College of Business & Economics
              Department of Business Administration
       College of Education & Public Policy
              School of Urban Affairs & Public Policy

Describe the rationale for the proposed program change(s):
(Explain your reasons for creating, revising, or deleting the curriculum or program.)

The Master of Science in Bioinformatics & Computational Biology (BICB-MS) will provide an interdisciplinary program to foster research collaborations across Colleges, and will support the future development of a PhD degree program in Bioinformatics & Computational Systems Biology. The thesis-based BICB-MS degree will prepare students for advanced research. The Life Sciences Concentration (LSC) will allow students with strong biological background to gain

solid knowledge and research experience in applying bioinformatics methods, tools and databases as an integral approach to life science research. The graduates may pursue further study towards a PhD or other professional degree, or a research career in academia, industry, or government agencies.

Program Requirements:
(Show the new or revised curriculum as it should appear in the Course Catalog. If this is a revision, be sure to indicate the changes being made to the current curriculum and **include a side-by-side comparison** of the credit distribution before and after the proposed change.)

BICB-MS Life Sciences Concentration (LSC) – Degree Requirement	
33 Credit Hours Total	
Bioinformatics & Computational Biology Core – Life Sciences	15 Credits
Ethics Core	3 Credits
Electives – Life Sciences	6 Credits
Thesis	6 Credits
Seminar	3 Credits (1 Credit/Semester, P/F)

BICB-MS Life Sciences Concentration (LSC) – Course Curriculum	
Bioinformatics & Computational Biology Core – Life Sciences (15)	
Bioinformatics (3)	ANFS644: Bioinformatics
Introduction to Discipline (3)	MAST697: Bioinformatics Programming for Biologists *
Systems Biology (3)	MAST698: Environmental and Systems Bioinformatics *
Database (3)	CISC637: Database Systems (3)
Biostatistics (3) [select one]	STAT613: Multivariate Statistical Methods with Biology Applications (3) *
	STAT656: Biostatistics (3)
Ethics Core (3)	
Ethics (3) [select one]	BISC631: Practice of Science (3)
	UAPP648: Environmental Ethics (3)
	UAPP650: Values Ethics and Leadership (3)
	BUAD840: Ethical Issues in Global Business Environments (3)
Electives – Life Sciences (6)	
Electives (6) [select two]	BISC600: Biotechnology and Molecular Medicine (3)
	BISC602: Molecular Biology of Animal Cells (3)
	BISC605 Advanced mammalian physiology (4)
	BISC612: Advanced Cell Biology (3)
	BISC615 Vertebrate Developmental Biology (3)
	BICS625: Cancer Biology (3)
	BISC641: Microbial Ecology (3)
	BISC645: Bacterial Evolution (3)
	BISC654: Biochemical Genetics (3)
	BISC656: Evolutionary Genetics (3)
	BISC665: Advanced Molecular Biology & Genetics (3)
	BISC671: Cellular and Molecular Immunology (3)
	BISC675: Cardiovascular Physiology (3)
	BISC679: Virology (3)

	BISC682: Bacterial Pathogens: Molecular Mechanisms (3)
	BISC693: Human Genetics (3)
	STAT670: Introduction to Statistical Analysis I (3) *
	STAT671: Introduction to Statistical Analysis II (3) *
	CHEM624: Principles of Mass Spectrometry (3)
	CHEM641: Biochemistry (3)
	CHEM645: Protein Structure and Function (3)
	CHEM646: DNA-Protein Interactions (3)
	CHEM649: Molecular Biophysics (3)
	ANFS670: Principles of Molecular Genetics (3)
	MAST616: Methods in Molecular Biology (3)
	MAST618: Marine Microbial Ecology (3)
	MAST623: Physiology of Marine Organisms (3)
	MAST625: Microbial Physiology and Diversity (3)
	MAST634: Marine Molecular Sciences (3)
	PLSC636: Plant Genes and Genomes (3) *
	PLSC644: Physiology of Plant Stress (3)
	HESC602: Data Analysis and Interpretation in Health Sciences (3)
	HESC654: Medical Physiology (3)
	PHYT606: Research (3)
	PHYT623: Clinical Neuroscience (4)
	PHYT633: Applied Physiology II (3)
Thesis (6)	
Thesis (6)	BINF869: Master's Thesis (1-6) *
Seminar (3)	
Seminar [3 semesters]	BINF865: Seminar (1) *

ROUTING AND AUTHORIZATION

(Please do not remove supporting documentation.)

Department Chairperson _____ Date_____

Dean of College_____ Date_____

Chairperson, College Curriculum Committee_____ Date_____

Chairperson, Senate Com. on UG or GR Studies_____ Date_____

Chairperson, Senate Coordinating Com._____ Date_____

Secretary, Faculty Senate_____ Date_____

Date of Senate Resolution_____ Date to be Effective_____

Registrar _____ Program Code_____ Date_____

Vice Provost for Academic Affairs & International Programs_____ Date_____

Provost _____ Date_____

Board of Trustee Notification _____ Date_____

Revised 10/23/2007 /khs

PROFESSIONAL SCIENCE MASTER'S IN BIOINFORMATICS: COMPUTATIONAL SCIENCES CONCENTRATION

Academic Program Approval

This form is a routing document for the approval of new and revised academic programs. Proposing department should complete this form. For more information, call the Faculty Senate Office at 831-2921.

Submitted by: _____Cathy H. Wu_____ phone number _____831-8869_____

Department: _____Computer & Information Sciences_____ email address _____wuc@udel.edu_____

Action: _____Request for New Professional Science Master's in Bioinformatics (BINF-PSM),_____ _____Computational Sciences Concentration (CS1)_____

(Example: add major/minor/concentration, delete major/minor/concentration, revise major/minor/concentration, academic unit name change, request for permanent status, policy change, etc.)

Effective term_____10F_____

(use format 04F, 05W)

Current degree _____N/A_____

(Example: BA, BACH, BACJ, HBA, EDD, MA, MBA, etc.)

Proposed change leads to the degree of: _____PSM_____

(Example: BA, BACH, BACJ, HBA, EDD, MA, MBA, etc.)

Proposed name: _____Professional Science Master's in Bioinformatics (BINF-PSM),_____ _____Computational Sciences Concentration (CS1)_____

Proposed new name for revised or new major / minor / concentration / academic unit
(if applicable)

Revising or Deleting:

    Undergraduate major / Concentration:_____

        (Example: Applied Music – Instrumental degree BMAS)

    Undergraduate minor:_____

        (Example: African Studies, Business Administration, English, Leadership, etc.)

    Graduate Program Policy statement change:_____

        (**Must attach** your Graduate Program Policy Statement)

    Graduate Program of Study:_____

        (Example: Animal Science: MS Animal Science: PHD Economics: MA Economics: PHD)

    Graduate minor / concentration:_____

Note: all graduate studies proposals must include an electronic copy of the Graduate Program Policy Document, highlighting the changes made to the original policy document.

List new courses required for the new or revised curriculum. How do they support the overall program objectives of the major/minor/concentrations)?
(Be aware that approval of the curriculum is dependent upon these courses successfully passing through the Course Challenge list. If there are no new courses enter "None")

CISC636: Bioinformatics (3) * submitted for re-title from "Introduction to Bioinformatics"
PLSC636: Plant Genes and Genomes (3) * submitted for re-title from "Advanced Plant Genetics"
MATH560: Introduction to Systems Biology (3) * adapted from MATH460
STAT613: Multivariate Statistical Methods with Biology Applications (3) * new course being developed
BINF864: Internship * new course listing
BINF865: Seminar * new course listing
BUAD500: Survey of Business (3) * new course being developed
STAT670: Introduction to Statistical Analysis I (3) * new course being developed
STAT671: Introduction to Statistical Analysis II (3) * new course being developed

Explain, when appropriate, how this new/revised curriculum supports the 10 goals of undergraduate education: http://www.ugs.udel.edu/gened/

    N/A

Identify other units affected by the proposed changes:
(Attach permission from the affected units. If no other unit is affected, enter "None")

    College of Arts & Sciences:
        Department of Biological Sciences
        Department of Mathematical Sciences
    College of Agriculture & Natural Resources
        Department of Plant & Soil Sciences
        Department of Food & Resource Economics
        Department of Animal & Food Sciences
    College of Engineering
        Department of Electrical & Computer Engineering
        Department of Chemical Engineering
    College of Earth, Ocean & Environment
        Marine Biosciences Program
    Alfred Lerner College of Business & Economics
        Department of Business Administration
        Department of Accounting & MIS
    College of Education & Public Policy
        School of Urban Affairs & Public Policy
    Office of the Vice Provost for Graduate & Professional Education
        Professional Education Initiatives

Describe the rationale for the proposed program change(s):
(Explain your reasons for creating, revising, or deleting the curriculum or program.)

The Professional Science Master's in Bioinformatics (BINF-PSM) will position UD as a regional leader in bioinformatics professional education. The scientific curriculum, together with "Plus" component for professional skills and the immersive Internship will well prepare the BINF-PSM graduates to pursue a career in industry, business, government agencies, or non-profit organizations. The Computational Sciences Concentration (CS1) will allow students with strong quantitative sciences background to gain solid knowledge and industry experience in developing bioinformatics methods, tools and/or databases for modern biotechnology or medicine.

Program Requirements:
(Show the new or revised curriculum as it should appear in the Course Catalog. If this is a revision, be sure to indicate the changes being made to the current curriculum and **include a side-by-side comparison** of the credit distribution before and after the proposed change.)

BINF-PSM Computational Sciences Concentration (CS1) – Degree Requirement	
42 Credit Hours Total	
Bioinformatics & Computational Biology Core – Computational Sciences	15 Credits
Ethics Core	3 Credits
Electives – Computational Sciences	6 Credits
Internship	6 Credits
Professional Science Master's Plus Courses (Business/ industry Track or Government/Non-Profit Track)	12 Credits

BINF-PSM Computational Sciences Concentration (CS1) – Course Curriculum	
Bioinformatics & Computational Biology Core – Computational Sciences (15)	
Bioinformatics (3)	CISC636: Bioinformatics (3) *
Introduction to Discipline (3) [select one]	ELEG671: Introduction to Biomedical Engineering (3)
	BISC602: Molecular Biology of Animal Cells (3)
	BISC612: Advanced Cell Biology (3)
	BISC654: Biochemical Genetics (3)
	PLSC636: Plant Genes and Genomes (3) *
	ANFS670: Principles of Molecular Genetics (3)
	MAST616: Methods in Molecular Biology (3)
Systems Biology (3)	MATH560: Introduction to Systems Biology (3) *
Database (3)	CISC637: Database Systems (3)
Biostatistics (3) [select one]	STAT613: Multivariate Statistical Methods with Biology Applications (3) *
	STAT656: Biostatistics (3)
Ethics Core (3)	
Ethics (3) [select one]	BISC631: Practice of Science (3)
	UAPP648: Environmental Ethics (3)
	UAPP650: Values Ethics and Leadership (3)
	BUAD840: Ethical Issues in Global Business Environments (3)
Electives – Computational Sciences (6)	
Electives (6) [select two]	CISC841: Algorithms in Bioinformatics (3)
	CISC621: Algorithm Design and Analysis (3)
	CISC640: Computer Graphics (3)

	CISC642: Introduction to Computer Vision (3)
	CISC650: Computer Networks (3)
	CISC675: Object Oriented Software Engineering (3)
	CISC681: Artificial Intelligence (3)
	CISC683: Introduction to Data mining (3)
	CISC882: Natural Language Processing (3)
	CISC886: Multi-Agent Systems (3)
	CISC887: Internet Information Gathering (3)
	CISC888: Machine Learning (3)
	MATH607: Survey of Scientific Computing (3)
	MATH611: Introduction to Numerical Analysis and Scientific Computing (3)
	STAT670: Introduction to Statistical Analysis I (3) *
	STAT671: Introduction to Statistical Analysis II (3) *
	STAT608: Statistical Research Methods (3)
	STAT615: Design and Analysis of Experiments (3)
	STAT619: Time Series Analysis (3)
	STAT621: Survival analysis (3)
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	ELEG633: Image Processing (3)
	ELEG652: Principles of Parallel Computer Architectures (3)
	ELEG655: High-Performance Computing with Commodity Hardware (3)
	ELEG679: Introduction to Medical Imaging Systems (3)
	ELEG680: Immunology for Engineers (3)
	CHEG620: Biochemical Engineering (3)
	CHEG621: Metabolic Engineering (3)
Internship (6)	
Internship (6)	BINF864: Internship (1-6) *
Professional Science Master's Plus Courses – Business/Industry Track † (12)	
Survey of Business (3)	BUAD500: Survey of Business (3) *
Leadership and Organization (3)	BUAD870: Leadership and Organizational Behavior (3)
Project Management, Operations or Entrepreneurship (3) [select one]	BUAD831: Operations Management and Management Science (3)
	BUAD835: Managing New Product Development Projects (3)
	BUAD871: Managing for Creativity and Innovation (3)
	ENTR860: High Technology Entrepreneurship (3)
	MISY840: Project Management and Costing (3)
Intellectual Property (3)	CHEG595: Intellectual Property for Engineers and Scientists (3)
Professional Science Master's Plus Courses – Government/Non-Profit Track † (12)	
Survey of Public Administration(3)	UAPP803: Seminar in Public Administration (3)
Leadership and Organization (3) [select one]	UAPP835: Organization and Management (3)
	UAPP604: Leadership in Organizations (3)
Managerial Decision Making or Financial Management (3) [select one]	UAPP819: Management Decision Making in Public & Nonprofit Sectors (3)
	UAPP833: Financial Management in Public & Nonprofit Sectors (3)
	UAPP827: Program and Project Analysis (3)
	UAPP829: Taxation and Fiscal Policies (3)

Legal and Regulatory Affairs (3)	UAPP646: Administrative Law and Policy (3)

† Students are recommended to follow one of the tracks, but may cross over tracks to fit interest.

ROUTING AND AUTHORIZATION
 (Please do not remove supporting documentation.)

Department Chairperson _____Date_____

Dean of College_____Date_____

Chairperson, College Curriculum Committee_____Date_____

Chairperson, Senate Com. on UG or GR Studies_____Date_____

Chairperson, Senate Coordinating Com._____Date_____

Secretary, Faculty Senate_____Date_____

Date of Senate Resolution_____Date to be Effective_____

Registrar _____Program Code_____Date_____

Vice Provost for Academic Affairs & International Programs_____Date_____

Provost _____Date_____

Board of Trustee Notification _____Date_____

Revised 10/23/2007 /khs

PROFESSIONAL SCIENCE MASTER'S IN BIOINFORMATICS: LIFE SCIENCES CONCENTRATION

Academic Program Approval

This form is a routing document for the approval of new and revised academic programs. Proposing department should complete this form. For more information, call the Faculty Senate Office at 831-2921.

Submitted by: _____Cathy H. Wu_____ phone number ___831-8869___

Department: ___Computer & Information Sciences___ email address __wuc@udel.edu__

Action: ___Request for New Professional Science Master's in Bioinformatics (BINF-PSM),___ ___Life Sciences Concentration (LSC1)___

(Example: add major/minor/concentration, delete major/minor/concentration, revise major/minor/concentration, academic unit name change, request for permanent status, policy change, etc.)

Effective term_____10F_____

(use format 04F, 05W)

Current degree _____N/A_____

(Example: BA, BACH, BACJ, HBA, EDD, MA, MBA, etc.)

Proposed change leads to the degree of: _____PSM_____

(Example: BA, BACH, BACJ, HBA, EDD, MA, MBA, etc.)

Proposed name: _____Professional Science Master's in Bioinformatics (PSM-BINF),_____ _____Life Sciences Concentration (LSC1)_____

Proposed new name for revised or new major / minor / concentration / academic unit
(if applicable)

Revising or Deleting:

Undergraduate major / Concentration:_____

(Example: Applied Music – Instrumental degree BMAS)

Undergraduate minor:_____

(Example: African Studies, Business Administration, English, Leadership, etc.)

Graduate Program Policy statement change:_____

(**Must attach** your Graduate Program Policy Statement)

Graduate Program of Study:_____

(Example: Animal Science: MS Animal Science: PHD Economics: MA Economics: PHD)

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Note: all graduate studies proposals must include an electronic copy of the Graduate Program Policy Document, highlighting the changes made to the original policy document.

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(Be aware that approval of the curriculum is dependent upon these courses successfully passing through the Course Challenge list. If there are no new courses enter "None")

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MAST698: Environmental and Systems Bioinformatics (3) * submitted for permanent status
STAT613: Multivariate Statistical Methods with Biology Applications (3) * new course being developed
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BINF865: Seminar * new course listing
BUAD500: Survey of Business (3) * new course being developed
STAT670: Introduction to Statistical Analysis I (3) * new course being developed
STAT671: Introduction to Statistical Analysis II (3) * new course being developed
PLSC636: Plant Genes and Genomes (3) * submitted for re-title from "Advanced Plant Genetics"

Explain, when appropriate, how this new/revised curriculum supports the 10 goals of undergraduate education: http://www.ugs.udel.edu/gened/

N/A

Identify other units affected by the proposed changes:
(Attach permission from the affected units. If no other unit is affected, enter "None")

College of Arts & Sciences:
        Department of Biological Sciences
        Department of Chemistry & Biochemistry
College of Agriculture & Natural Resources
        Department of Plant & Soil Sciences
        Department of Food & Resource Economics
        Department of Animal & Food Sciences
College of Engineering
        Department of Chemical Engineering
College of Earth, Ocean & Environment
        Marine Biosciences Program
College of Health Sciences
        Department of Health, Nutrition & Exercise Sciences
        Department of Physical Therapy
Alfred Lerner College of Business & Economics
        Department of Business Administration
        Department of Accounting & MIS
College of Education & Public Policy
        School of Urban Affairs & Public Policy
Office of the Vice Provost for Graduate & Professional Education
        Professional Education Initiatives

Describe the rationale for the proposed program change(s):
(Explain your reasons for creating, revising, or deleting the curriculum or program.)

The Professional Science Master's in Bioinformatics (BINF-PSM) will position UD as a regional leader in bioinformatics professional education. The scientific curriculum, along with "Plus" component for professional skills and the immersive Internship will well prepare the BINF-PSM graduates to pursue a career in industry, business, government agencies, or non-profit organizations. The Life Sciences Concentration (LSC1) will allow students with strong biological sciences background to gain solid knowledge and industry experience in applying bioinformatics methods, tools and databases as an integral approach to modern biotechnology and medicine.

Program Requirements:
(Show the new or revised curriculum as it should appear in the Course Catalog. If this is a revision, be sure to indicate the changes being made to the current curriculum and **include a side-by-side comparison** of the credit distribution before and after the proposed change.)

BINF-PSM Life Sciences Concentration (LSC1) – Degree Requirement	
42 Credit Hours Total	
Bioinformatics & Computational Biology Core – Life Sciences	15 Credits
Ethics Core	3 Credits
Electives – Life Sciences	6 Credits
Internship	6 Credits
Professional Science Master's Plus Courses (Business/ industry Track or Government/Non-Profit Track)	12 Credits

BINF-PSM Life Sciences Concentration (LSC1) – Course Curriculum	
Bioinformatics & Computational Biology Core – Life Sciences (15)	
Bioinformatics (3)	ANFS644: Bioinformatics
Introduction to Discipline (3)	MAST697: Bioinformatics Programming for Biologists *
Systems Biology (3)	MAST698: Environmental and Systems Bioinformatics *
Database (3)	CISC637: Database Systems (3)
Biostatistics (3) [select one]	STAT613: Multivariate Statistical Methods with Biology Applications (3) *
	STAT656: Biostatistics (3)
Ethics Core (3)	
Ethics (3) [select one]	BISC631: Practice of Science (3)
	UAPP648: Environmental Ethics (3)
	UAPP650: Values Ethics and Leadership (3)
	BUAD840: Ethical Issues in Global Business Environments (3)
Electives – Life Sciences (6)	
Electives (6) [select two]	BISC600: Biotechnology and Molecular Medicine (3)
	BISC602: Molecular Biology of Animal Cells (3)
	BISC605 Advanced mammalian physiology (4)
	BISC612: Advanced Cell Biology (3)
	BISC615 Vertebrate Developmental Biology (3)
	BICS625: Cancer Biology (3)

	BISC641: Microbial Ecology (3)
	BISC645: Bacterial Evolution (3)
	BISC654: Biochemical Genetics (3)
	BISC656: Evolutionary Genetics (3)
	BISC665: Advanced Molecular Biology & Genetics (3)
	BISC671: Cellular and Molecular Immunology (3)
	BISC675: Cardiovascular Physiology (3)
	BISC679: Virology (3)
	BISC682: Bacterial Pathogens: Molecular Mechanisms (3)
	BISC693: Human Genetics (3)
	STAT670: Introduction to Statistical Analysis I (3) *
	STAT671: Introduction to Statistical Analysis II (3) *
	CHEM624: Principles of Mass Spectrometry (3)
	CHEM641: Biochemistry (3)
	CHEM645: Protein Structure and Function (3)
	CHEM646: DNA-Protein Interactions (3)
	CHEM649: Molecular Biophysics (3)
	ANFS670: Principles of Molecular Genetics (3)
	MAST616: Methods in Molecular Biology (3)
	MAST618: Marine Microbial Ecology (3)
	MAST623: Physiology of Marine Organisms (3)
	MAST625: Microbial Physiology and Diversity (3)
	MAST634: Marine Molecular Sciences (3)
	PLSC636: Plant Genes and Genomes (3) *
	PLSC644: Physiology of Plant Stress (3)
	HESC602: Data Analysis and Interpretation in Health Sciences (3)
	HESC654: Medical Physiology (3)
	PHYT606: Research (3)
	PHYT623:Clinical Neuroscience (4)
	PHYT633:Applied Physiology II (3)
Internship (6)	
Internship (6)	BINF864: Internship (1-6) *
Professional Science Master's Plus Courses – Business/Industry Track † (12)	
Survey of Business (3)	BUAD500: Survey of Business (3) *
Leadership and Organization (3)	BUAD870: Leadership and Organizational Behavior (3)
Project Management, Operations or Entrepreneurship (3) [select one]	BUAD831: Operations Management and Management Science (3)
	BUAD835: Managing New Product Development Projects (3)
	BUAD871: Managing for Creativity and Innovation (3)
	ENTR860: High Technology Entrepreneurship (3)
	MISY840: Project Management and Costing (3)
Intellectual Property (3)	CHEG595: Intellectual Property for Engineers and Scientists (3)
Professional Science Master's Plus Courses – Government/Non-Profit Track † (12)	
Survey of Public Administration(3)	UAPP803: Seminar in Public Administration (3)
Leadership and Organization (3)	UAPP835: Organization and Management (3)
	UAPP604: Leadership in Organizations (3)

[select one]	
Managerial Decision Making or Financial Management (3)	UAPP819: Management Decision Making in Public & Nonprofit Sectors (3)
	UAPP833: Financial Management in Public & Nonprofit Sectors (3)
	UAPP827: Program and Project Analysis (3)
[select one]	UAPP829: Taxation and Fiscal Policies (3)
Legal and Regulatory Affairs (3)	UAPP646: Administrative Law and Policy (3)

† Students are recommended to follow one of the tracks, but may cross over tracks to fit interest.

ROUTING AND AUTHORIZATION
(Please do not remove supporting documentation.)

Department Chairperson _____ Date_____

Dean of College_____ Date_____

Chairperson, College Curriculum Committee_____ Date_____

Chairperson, Senate Com. on UG or GR Studies_____ Date_____

Chairperson, Senate Coordinating Com._____ Date_____

Secretary, Faculty Senate_____ Date_____

Date of Senate Resolution_____ Date to be Effective_____

Registrar _____ Program Code_____ Date_____

Vice Provost for Academic Affairs & International Programs_____ Date_____

Provost _____ Date_____

Board of Trustee Notification _____ Date_____

Revised 10/23/2007 /khs

GRADUATE CERTIFICATE IN BIOINFORMATICS: COMPUTATIONAL SCIENCES CONCENTRATION

Academic Program Approval

This form is a routing document for the approval of new and revised academic programs. Proposing department should complete this form. For more information, call the Faculty Senate Office at 831-2921.

Submitted by: _____Cathy H. Wu_____ phone number _____831-8869_____

Department: _____Computer & Information Sciences_____ email address _____wuc@udel.edu_____

Action: _____Request for New Graduate Certificate in Bioinformatics (BINF-CERT),_____
_____Computational Sciences Concentration (CS2)_____
(Example: add major/minor/concentration, delete major/minor/concentration, revise major/minor/concentration, academic unit name change, request for permanent status, policy change, etc.)

Effective term_____10F_____
(use format 04F, 05W)

Current degree _____N/A_____
(Example: BA, BACH, BACJ, HBA, EDD, MA, MBA, etc.)

Proposed change leads to the degree of: _____Graduate Certificate_____
(Example: BA, BACH, BACJ, HBA, EDD, MA, MBA, etc.)

Proposed name: _____Graduate Certificate in Bioinformatics (BINF-CERT),_____
_____Computational Sciences Concentration (CS2)_____
Proposed new name for revised or new major / minor / concentration / academic unit
(if applicable)

Revising or Deleting:

    Undergraduate major / Concentration:_____
                    (Example: Applied Music – Instrumental degree BMAS)

    Undergraduate minor:_____
              (Example: African Studies, Business Administration, English, Leadership, etc.)

    Graduate Program Policy statement change:_____
                 (**Must attach** your Graduate Program Policy Statement)

    Graduate Program of Study:_____
           (Example: Animal Science: MS Animal Science: PHD Economics: MA Economics: PHD)

    Graduate minor / concentration:_____

Note: all graduate studies proposals must include an electronic copy of the Graduate Program Policy Document, highlighting the changes made to the original policy document.

List new courses required for the new or revised curriculum. How do they support the overall program objectives of the major/minor/concentrations)?
(Be aware that approval of the curriculum is dependent upon these courses successfully passing through the Course Challenge list. If there are no new courses enter "None")

CISC636: Bioinformatics (3) * submitted for re-title from "Introduction to Bioinformatics"
PLSC636: Plant Genes and Genomes (3) * submitted for re-title from "Advanced Plant Genetics"
MATH560: Introduction to Systems Biology (3) * adapted from MATH460
STAT613: Multivariate Statistical Methods with Biology Applications (3) * new course being developed

Explain, when appropriate, how this new/revised curriculum supports the 10 goals of undergraduate education: http://www.ugs.udel.edu/gened/

      N/A

Identify other units affected by the proposed changes:
(Attach permission from the affected units. If no other unit is affected, enter "None")

      College of Arts & Sciences:
            Department of Biological Sciences
            Department of Mathematical Sciences
      College of Agriculture & Natural Resources
            Department of Plant & Soil Sciences
            Department of Food & Resource Economics
            Department of Animal & Food Sciences
      College of Engineering
            Department of Electrical & Computer Engineering
      College of Earth, Ocean & Environment
            Marine Biosciences Program

Describe the rationale for the proposed program change(s):
(Explain your reasons for creating, revising, or deleting the curriculum or program.)

The Graduate Certificate in Bioinformatics (BINF-CERT) will provide bioinformatics core competency. It is ideally suited for working professionals who cannot make a commitment to the BICB-MS or BINF-PSM program at this time, but can use the Certificate as a stepping stone. Current graduate students at UD can use the Certificate to gain bioinformatics skills. The Computational Sciences Concentration (CS2) will allow students with strong quantitative sciences background to gain knowledge in developing bioinformatics methods, tools and/or databases for modern biotechnology or medicine.

Program Requirements:
(Show the new or revised curriculum as it should appear in the Course Catalog. If this is a revision, be sure to indicate the changes being made to the current curriculum and **include a side-by-side comparison** of the credit distribution before and after the proposed change.)

BINF-CERT: Computational Sciences Concentration (CS2) – Degree Requirement	
15 Credit Hours Total	
Bioinformatics & Computational Biology Core – Computational Sciences	15 Credits

BINF-CERT: Computational Sciences Concentration (CS2) – Course Curriculum	
Bioinformatics (3)	CISC636: Bioinformatics (3) *
Introduction to Discipline (3) [select one]	ELEG671: Introduction to Biomedical Engineering (3)
	BISC602: Molecular Biology of Animal Cells (3)
	BISC612: Advanced Cell Biology (3)
	BISC654: Biochemical Genetics (3)
	PLSC636: Plant Genes and Genomes (3) *
	ANFS670: Principles of Molecular Genetics (3)
	MAST616: Methods in Molecular Biology (3)
Systems Biology (3)	MATH560: Introduction to Systems Biology (3) *
Database (3)	CISC637: Database Systems (3)
Biostatistics (3) [select one]	STAT613: Multivariate Statistical Methods with Biology Applications (3) *
	STAT656: Biostatistics (3)

ROUTING AND AUTHORIZATION
 (Please do not remove supporting documentation.)

Department Chairperson _____ Date_____

Dean of College_____ Date_____

Chairperson, College Curriculum Committee_____Date_____

Chairperson, Senate Com. on UG or GR Studies_____Date_____

Chairperson, Senate Coordinating Com._____Date_____

Secretary, Faculty Senate_____Date_____

Date of Senate Resolution_____Date to be Effective_____

Registrar _____Program Code_____Date_____

Vice Provost for Academic Affairs & International Programs_____Date_____

Provost _____Date_____

Board of Trustee Notification _____Date_____

Revised 10/23/2007 /khs

GRADUATE CERTIFICATE IN BIOINFORMATICS: LIFE SCIENCES CONCENTRATION

Academic Program Approval

This form is a routing document for the approval of new and revised academic programs. Proposing department should complete this form. For more information, call the Faculty Senate Office at 831-2921.

Submitted by: _____Cathy H. Wu_____ phone number ___831-8869_____

Department: ____Computer & Information Sciences____ email address __wuc@udel.edu__

Action: _____Request for New Graduate Certificate in Bioinformatics (BINF-CERT), _____
_____Life Sciences Concentration (LSC2)_____
<div style="text-align:center">(Example: add major/minor/concentration, delete major/minor/concentration, revise major/minor/concentration, academic unit name change, request for permanent status, policy change, etc.)</div>

Effective term_____10F_____
<div style="text-align:center">(use format 04F, 05W)</div>

Current degree _____N/A_____
<div style="text-align:center">(Example: BA, BACH, BACJ, HBA, EDD, MA, MBA, etc.)</div>

Proposed change leads to the degree of: _____Graduate Certificate_____
<div style="text-align:center">(Example: BA, BACH, BACJ, HBA, EDD, MA, MBA, etc.)</div>

Proposed name: _____Graduate Certificate in Bioinformatics (BINF-CERT), _____
_____Life Sciences Concentration (LSC2)_____
<div style="text-align:center">Proposed new name for revised or new major / minor / concentration / academic unit
(if applicable)</div>

Revising or Deleting:

    Undergraduate major / Concentration:_____
<div style="text-align:center">(Example: Applied Music – Instrumental degree BMAS)</div>

    Undergraduate minor:_____
<div style="text-align:center">(Example: African Studies, Business Administration, English, Leadership, etc.)</div>

    Graduate Program Policy statement change:_____
<div style="text-align:center">(**Must attach** your Graduate Program Policy Statement)</div>

    Graduate Program of Study:_____
<div style="text-align:center">(Example: Animal Science: MS Animal Science: PHD Economics: MA Economics: PHD)</div>

    Graduate minor / concentration:_____

Note: all graduate studies proposals must include an electronic copy of the Graduate Program Policy Document, highlighting the changes made to the original policy document. List new courses required for the new or revised curriculum. How do they support the overall program objectives of the major/minor/concentrations)?
(Be aware that approval of the curriculum is dependent upon these courses successfully passing through the Course Challenge list. If there are no new courses enter "None")

MAST697: Bioinformatics Programming for Biologists (3) * submitted for permanent status
MAST698: Environmental and Systems Bioinformatics (3) * submitted for permanent status
STAT613: Multivariate Statistical Methods with Biology Applications (3) * new course being developed

Explain, when appropriate, how this new/revised curriculum supports the 10 goals of undergraduate education: http://www.ugs.udel.edu/gened/

N/A

Identify other units affected by the proposed changes:
(Attach permission from the affected units. If no other unit is affected, enter "None")

College of Agriculture & Natural Resources
Department of Food & Resource Economics
Department of Animal & Food Sciences
College of Earth, Ocean & Environment
Marine Biosciences Program

Describe the rationale for the proposed program change(s):
(Explain your reasons for creating, revising, or deleting the curriculum or program.)

The Graduate Certificate in Bioinformatics (BINF-CERT) will provide bioinformatics core competency. It is ideally suited for working professionals who cannot make a commitment to the BICB-MS or BINF-PSM program at this time, but can use the Certificate as a stepping stone. Current Master's or PhD students at UD can use the Certificate to gain bioinformatics skills. The Life Sciences Concentration (LSC2) will allow students with strong biological background to gain knowledge in applying bioinformatics methods, tools and databases as an integral approach to modern biotechnology or medicine.

Program Requirements:
(Show the new or revised curriculum as it should appear in the Course Catalog. If this is a revision, be sure to indicate the changes being made to the current curriculum and **include a side-by-side comparison** of the credit distribution before and after the proposed change.)

BINF-CERT: Life Sciences Concentration (LSC2) – Degree Requirement	
15 Credit Hours Total	
Bioinformatics & Computational Biology Core – Life Sciences	15 Credits

BINF-CERT: Life Sciences Concentration (LSC2) – Course Curriculum	
Bioinformatics (3)	ANFS644: Bioinformatics
Introduction to Discipline (3)	MAST697: Bioinformatics Programming for Biologists *

Systems Biology (3)	MAST698: Environmental and Systems Bioinformatics *
Database (3)	CISC637: Database Systems (3)
Biostatistics (3)	STAT613: Multivariate Statistical Methods with Biology Applications (3) *
[select one]	STAT656: Biostatistics (3)

ROUTING AND AUTHORIZATION
 (Please do not remove supporting documentation.)

Department Chairperson _____ Date_____

Dean of College_____ Date_____

Chairperson, College Curriculum Committee_____Date_____

Chairperson, Senate Com. on UG or GR Studies_____Date_____

Chairperson, Senate Coordinating Com._____Date_____

Secretary, Faculty Senate_____ Date_____

Date of Senate Resolution_____ Date to be Effective_____

Registrar _____Program Code_____Date_____

Vice Provost for Academic Affairs & International Programs_____Date_____

Provost _____ Date_____

Board of Trustee Notification _____ Date_____

Revised 10/23/2007 /khs

APPENDIX - Course Descriptions

Bioinformatics & Computational Biology Core – Computational Sciences

- **Bioinformatics**

  CISC636: Bioinformatics (3)
  - Introduction to concepts, methodologies, and tools in bioinformatics. Abstraction of biological problems for computational solutions. Genome sequencing and assembly, bio-sequence comparison and database search, dynamics programming, hidden Markov models, and phylogenetic trees. PREREQ: CISC220 or permission of instructor. TERM: Fall Semester

- **Introduction to Discipline**

  ELEG671: Introduction to Biomedical Engineering (3)
  - Mathematical methods in Human Physiology. Introduction to human physiology from a systems perspective, covering all hierarchical levels including molecular, biochemical, cellular, tissue, organ, and integrated systems. Dynamic modeling of physiologic systems including homeostatic control systems, endocrine regulatory systems, immune response dynamics, mutation, selection and evolution. Mathematical methods covered include linear and nonlinear ordinary differential equations, Lyapunov stability analysis, mass action kinetics, Hamming spaces, reaction-diffusion equations, and numerical simulation. TERM: Fall Semester.

  BISC602: Molecular Biology of Animal Cells (3)
  - Examination of eucaryotic genes, synthesis and processing of messenger RNA and control of protein synthesis with emphasis on regulation of normal cellular growth and differentiation and the process of cancer cell transformation. Emphasis on recombinant DNA technology, monoclonal antibody production and tissue culture. PREREQ: BISC401 and BISC403. Requires permission from the instructor. TERM: Fall Semester

  BISC612: Advanced Cell Biology (3)
  - Four major sections: (1) cell structure/function; (2) signaling mechanisms and cell fate; (3) protein biosynthesis and trafficking and (4) integrative cell biology. Requires interpreting and evaluating data from primary scientific literature. Meets literature requirement for biology majors.

  BISC654: Biochemical Genetics (3)
  - Covers the use of genetic model organisms to answer biological questions, including mapping and cloning of human disease genes and the creation of animal models for human genetic diseases. There is an emphasis on examples from the recent scientific literature and building scientific writing skills. PREREQ: BISC403 and BISC401; or permission of instructor

  PLSC636: Plant Genes and Genomes (3)
  - Advanced survey of molecular genetics in higher plants, including molecular methods of plant biotechnology. Topics include genome composition and

evolution, transposable elements and retrotransposons, DNA methylation and epigenetics, small RNAs, quantitative traits, chromosome structure and gene expression. PREREQ: PLSC300 and PLSC306.

ANFS670: Principles of Molecular Genetics (3)

- Fundamentals of nucleic acid biochemistry (replication, repair, and recombination) and bacterial genetics provide the background needed for detailed study of selected topics in animal and plant molecular biology. PREREQ: ANFS300 or permission of instructor.

MAST616: Methods in Molecular Biology (3)

- Conceptual experience in molecular biological techniques with an emphasis on their application to marine related problems. Topics include: nucleic acid extractions, cloning, gene amplification and characterization, and expression methodologies. PREREQ: MAST634

- **Systems Biology**

MATH560: Introduction to Systems Biology (3)

- Systems biology approach, mathematical modeling of biological systems; examples from biomedical and agricultural research areas, biotechnology, industrial processes, and others. Differential equations, stochastic, feedback and control, or network models are discussed. Hands-on work via PBL modules. PREREQ: CHEM527, MATH535 and one of BISC302, 305, 306, 401 or 403.

- **Database**

CISC637: Database Systems (3)

- Physical and logical organization of databases. Data retrieval languages, relational database languages, security and integrity, concurrency, distributed databases. PREREQ: CISC220 and CISC304 or equivalent. TERM: Fall Semester

- **Biostatistics**

STAT613: Multivariate Statistical Methods with Biology Applications (3)

- Emphasis on applying multivariate statistical methods in biology. Principal component, factor analysis, discriminant analysis, cluster analysis, and canonical correlation methods are applied for data sets in biology.

STAT656: Biostatistics (3)

- An introduction to statistics focused toward applications in biological, medical and other life sciences. Topics include graphical and numerical techniques, random variables and their distribution, estimation and inference. PREREQ: MATH201

BIOINFORMATICS & COMPUTATIONAL BIOLOGY CORE – LIFE SCIENCES

- **Bioinformatics**

ANFS644: Bioinformatics (3)

- Examines computer applications to biological sciences with emphasis placed upon genomics and proteomics applications. No computer programming experience required. TERM: Fall Semester

- **Introduction to Discipline**

MAST697: Bioinformatics Programming for Biologists (3)

- Basic PERL programming for biologists interested in doing bioinformatics research but who have no prior experience in computer programming. The goal is to familiarize students with PERL syntax sufficiently so that they will be able to edit and trouble-shoot existing PERL programs and modules to suite their own research needs without having to write their own de novo programs and scripts. Students are given class accounts on the Biowolf parallel computing cluster at DBI. Students are also expected to become proficient at working with computers from a command-line, unix-based, terminal interface.
- **Systems Biology**
  MAST698: Environmental and Systems Bioinformatics (3)
  - Use bioinformatic methods to link genomic/proteomic sequence features to specific mechanisms of environmental adaptations or metabolic systems organization. It is designed for graduate students and advanced undergraduates wanting to apply basic informatic approaches and computational tools to specific research topics that interest them. Students are expected to have some experience with programming (i.e., MAST697). Computational tools presented to students include: PERL, PYTHON, R, and MatLab. It is expected that students will conduct an individual research project as a component of this course.
- **Database**
  CISC637: Database Systems (3)
  - Physical and logical organization of databases. Data retrieval languages, relational database languages, security and integrity, concurrency, distributed databases. PREREQ: CISC220 and CISC304 or equivalent. TERM: Fall Semester
- **Biostatistics**
  STAT613: Multivariate Statistical Methods with Biology Applications (3)
  - Emphasis on applying multivariate statistical methods in biology. Principal component, factor analysis, discriminant analysis, cluster analysis, and canonical correlation methods are applied for data sets in biology.
  STAT656: Biostatistics (3)
  - An introduction to statistics focused toward applications in biological, medical and other life sciences. Topics include graphical and numerical techniques, random variables and their distribution, estimation and inference. PREREQ: MATH201

ETHICS CORE

BIOL631: Practice of Science (3)
- Uses historical, philosophical, and sociological perspectives to better understand the nature of modern science and its practice. Examines "science misconduct," and satisfies the NIH mandate requiring graduate training in "the responsible conduct of research."

UAPP648: Environmental Ethics (3)
- Ethical problems associated with environmental protection, local, national, and international. Relations to social and political movements. Seminar format.

UAPP650: Values Ethics and Leadership (3)

- Looks at the "ends" served by leaders in various contexts (including government, nonprofits, business, and media) and the ethical standards by which the leaders' actions are judged. Examines cases of unethical conduct as well as cases of exemplary conduct.

BUAD840: Ethical Issues in Global Business Environments (3)
- Topics include ethics in organizations, and problems and challenges dealing with external environment demands including global issues.

BIOINFORMATICS & COMPUTATIONAL BIOLOGY INTERNSHIP/SEMINAR/THESIS

BINF864: Internship (1-6)
- Supervised, on-the-job experience on specialized topics in bioinformatics or on industry research and analysis related to bioinformatics. Specialized topics may range from bioinformatics method, tool and database development to the application of bioinformatics approaches to biotechnology and medicine. Industry research and analysis may include topics on product development, project or operations management, and ethical, legal and regulatory affairs.

BINF865: Seminar (1)
- Lectures and discussions by guest speakers, faculty, and students on specialized topics and cutting-edge developments in bioinformatics and computational biology.

BINF869: Master's Thesis (1-6)
- Independent, supervised research leading to the Master's Thesis on specialized topics in bioinformatics and computational biology ranging from computational genomics and structural bioinformatics to systems biology and high performance biomedical computing. The research may involve the development of computational methods and bioinformatics tools and databases for the study of biological systems, or the application of bioinformatics methods, tools and databases as an integral approach to life science research.

ELECTIVES – COMPUTATIONAL SCIENCES

CISC841: Algorithms in Bioinformatics (3)
- Advanced topics in current bioinformatics research, such as hidden Markov models, kernel based methods, and bayesian based analysis with applications to functional annotation, structural prediction, and biological networks inferences. PREREQ: CISC436 or CISC636 or permission of instructor.

CISC621: Algorithm Design and Analysis (3)
- Emphasis on developing expertise in the design and analysis of algorithms. Equal importance given to techniques and specific algorithms. Particular topics include advanced data structures, graph algorithms, disjoint set manipulation, sorting and selection, amortized analysis, NP-completeness, and matrix and polynomial multiplication. PREREQ: Undergraduate algorithms and discrete math courses. TERM: Fall Semester

CISC640: Computer Graphics (3)

- Computer graphics technology, two- and three-dimensional systems, graphics software systems, modeling and object hierarchy, and animation. PREREQ: CISC220 or equivalent. COREQ: CISC320 recommended. TERM: Fall Semester

CISC642: Introduction to Computer Vision (3)

- An introduction to the analysis of images and video to recognize, reconstruct, model, and otherwise infer static and dynamic properties of objects in the three-dimensional world. Geometry of image formation; image processing such as smoothing, edge and feature detection, color, and texture; segmentation; shape representation including deformable templates; stereo vision; motion estimation and tracking; techniques for 3-D reconstruction; image registration methods. PREREQ: CISC220 equivalent

CISC650: Computer Networks (3)

- Foundation principles, architectures, and techniques employed in computer and communication networks. Focuses on mechanisms used in TCP/IP protocol suite. Topics include connection management, end-to-end reliable data transfer, sliding window protocols, quality of service, flow control, congestion control, routing, LANs, framing, error control, analog versus digital transmission, packet versus circuit switching, multiplexing. PREREQ: CISC360, CISC361 or CISC663

CISC675: Object Oriented Software Engineering (3)

- Understand and apply a complete modern software engineering process. Topics include requirements analysis, specification, design, implementation, verification, and project management. Real-life team projects cover all aspects of software development lifecycle, from requirements to acceptance testing. Use of formal methods in the specification, design, and verification of software will be explored.

CISC681: Artificial Intelligence (3)

- Programming techniques for problems not amenable to algorithmic solutions. Problem formulation, search strategies, state spaces, applications of logic, knowledge representation, planning and application areas. PREREQ: CISC220 and CISC304 or equivalent. TERM: Fall Semester

CISC683: Introduction to Data mining (3)

- Concepts, techniques, and algorithms for mining large data sets to discover structural patterns that can be used to make subsequent predictions. Emphasis on practical approaches and empirical evaluation. Use of a workbench of data mining tools, such as the Weka toolkit.

CISC882: Natural Language Processing (3)

- Introduction to computational models of syntax, semantics and pragmatics for natural language understanding. Emphasis on design of English interfaces to data bases and ill-formed input. PREREQ: CISC681. TERM: Fall Semester

CISC886: Multi-Agent Systems (3)

- Introduction to the field of Multi-Agent Systems, examining issues that arise when groups of self-interested or cooperating autonomous agents interact to solve shared problems. Issues include reasoning about the knowledge and beliefs of other agents, communication and negotiation, computational organization, coordination and control. PREREQ: CISC681 or equivalent

CISC887: Internet Information Gathering (3)

- Approaches to information gathering, filtering, and integration including work in the heterogeneous database, information retrieval and agent-oriented communities. Text indexing, vector-based and probabilistic retrieval, semantic web technologies, wrappers and mediators, query planning and optimization, collaborative filtering, information agents, applications. PREREQ: CISC681 or equivalent

CISC888: Machine Learning (3)
- Concepts and algorithms underlying computer programs that learn from data to solve a task will be discussed. A range of modern machine learning algorithms will be covered.

MATH607: Survey of Scientific Computing (3)
- Numerical solution of linear systems; interpolation; differentiation and quadrature; transforms/FFT; nonlinear equations; initial value problems; boundary value problems; Monte Carlo methods; finite difference methods for partial differential equations. Additional topics at the discretion of the instructor. PREREQ: Linear algebra, differential equations, multivariable calculus. TERM: Fall Semester

MATH611: Introduction to Numerical Analysis and Scientific Computing (3)
- Introduction to numerical computing, analysis and solution of systems of linear equations, linear least-squares, eigenvalue problems, methods for unconstrained optimization, solution of systems of nonlinear equations. Experience with standard computer packages, code development and simulations of applied problems. PREREQ: Linear algebra and multivariate calculus. TERM: Fall Semester

STAT670: Introduction to Statistical Analysis I (3)
- Basic probability; continuous, discrete and joint distributions; distribution of functions of random variables; order statistics; expected value and central limit theorem.

STAT671: Introduction to Statistical Analysis II (3)
- Distributions of common statistics, sampling techniques, estimation, confidence intervals, hypotheses testing and selected topics.

STAT608: Statistical Research Methods (3)
- Experimental design and plot plans, collection, analysis and presentation of data in agricultural and biological research. TERM: Fall Semester

STAT615: Design and Analysis of Experiments (3)
- Fundamental principles of design, randomized designs, Latin squares, sources of error, components of error. Factorial designs, response surfaces, models for design. PREREQ: STAT371. TERM: Fall Semester

STAT619: Time Series Analysis (3)
- Fundamental topics in time series analysis - features the Box and Jenkins techniques of fitting time series data. Includes an introduction to appropriate statistical packages.

STAT621: Survival Analysis (3)
- Statistical techniques used in the analysis of censored data including the Kaplan-Meier estimator, the analysis of one, two and K sample problems, and regression

analysis based on the Cox proportional hazards model. RESTRICTIONS: Requires permission of instructor.

STAT674: Applied Data Base Management (3)

- Provides an in-depth understanding of using computers to manage data using programs such as SAS and Microsoft/Access. RESTRICTIONS: Requires permission of instructor. TERM: Fall Semester

ELEG633: Image Processing (3)

- Review of concepts of linear systems and spectral analysis, human visual response, scanning and display of images, Fourier optics, image enhancement and feature extraction, design of digital filters for image processing, 2D fast Fourier transform algorithms and computed tomography. RESTRICTIONS: Requires permission of instructor. TERM: Spring Semester (may not be offered every year)

ELEG652: Principles of Parallel Computer Architectures (3)

- Provides an introduction to the principles of parallel computer architecture. Begins at a level that assumes experience in introductory undergraduate courses such as digital system design, computer architecture, and microprocessor based systems. TERM: Spring Semester

ELEG655: High-Performance Computing with Commodity Hardware (3)

- New commodity computing devices, e.g., GPUs, bring the originally elite high performance computing into the reach of general public. Principles of program optimization, GPU and IBM Cell architecture, along with concepts and techniques for optimizing general purpose computing on the new hardware. TERM: Fall Semester

ELEG679: Introduction to Medical Imaging Systems (3)

- Physics, instrumentation, system design, and image reconstruction algorithms will be covered for the following modalities: radiography, x-ray computed tomography (CT), single photon emission computed tomography (SPECT), positron emission tomography (PET), magnetic resonance imaging (MRI), and real-time ultrasound. RESTRICTIONS: Requires permission of instructor. TERM: Spring Semester

ELEG680: Immunology for Engineers (3)

- Human adaptive immune response to viruses, both cellular and humoral. Generation of the immune response cells and response to types of immunogen as well as basic nonlinear differential model analysis, basic mathematical models of their interactions and implications of these models for the treatment of disease. Access significant amount of current literature. No prior knowledge of biology required. RESTRICTIONS: Requires permission of instructor. TERM: Spring Semester (may not be offered every year)

CHEG620: Biochemical Engineering (3)

- Application of chemical engineering principles to analyze different molecular engineering approaches, evaluate bioreactors and product recovery processes, analyze cellular engineering approaches and critically evaluate primary bioengineering data from literature and laboratory experiments. PREREQ: MATH243 and CHEM527 or CHEM641 and CHEM642. TERM: Fall Semester

CHEG621: Metabolic Engineering (3)

- Focuses on design and control of cellular metabolism and includes analysis of metabolic function using systems engineering and molecular biology tools. Goals are to learn computational approaches for analyzing metabolic behavior, and experimental techniques to measure cellular components, metabolites, proteins and nucleic acids. PREREQ: CHEM527 or CHEM641; MATH305.

ELECTIVES – LIFE SCIENCES

BISC600: Biotechnology and Molecular Medicine (3)
- Application of molecular and cellular biology techniques and principles to the field of biotechnology. Stresses the applied side of science and focuses on the practical side of molecular biology and how scientists and companies reduce the basic knowledge to practice. Emphasis on product formation and the skills required to meet such goals. Covers tangential issues of biotechnology and the ethical choices made in developing clinical trial protocols. PREREQ: Undergraduate course in biology or chemistry or permission of the instructor.

BISC602: Molecular Biology of Animal Cells (3)
- Examination of eucaryotic genes, synthesis and processing of messenger RNA and control of protein synthesis with emphasis on regulation of normal cellular growth and differentiation and the process of cancer cell transformation. Emphasis on recombinant DNA technology, monoclonal antibody production and tissue culture. PREREQ: BISC401 and BISC403. Requires permission from the instructor. TERM: Fall Semester

BISC605: Advanced mammalian physiology (4)
- Systemic mammalian physiology: cellular mechanisms, muscle, cardiovascular, respiratory, renal, digestive and endocrine systems. Emphasizes human physiology and includes discussions of primary literature in the field of physiology research. PREREQ: BISC306 or instructor's approval.

BISC612: Advanced Cell Biology (3)
- Four major sections: (1) cell structure/function; (2) signaling mechanisms and cell fate; (3) protein biosynthesis and trafficking and (4) integrative cell biology. Requires interpreting and evaluating data from primary scientific literature. Meets literature requirement for biology majors.

BISC615 Vertebrate Developmental Biology (3)
- Introduces the basic principles of vertebrate development including formation of the basic body plan and the molecular control of tissue morphogenesis. The importance of each developmental milestone will be illustrated by discussing the underlying causes of birth defects. PREREQ: BISC401 and BISC403. Requires instructor approval.

BICS625: Cancer Biology (3)
- Provides an integrated lecture series summarizing current knowledge in cancer biology. Topics include: statistics of incidence/survival, pathology, the process of chemical carcinogenesis and sources of carcinogens, genetic and epigenetic mechanisms and consequences, viral and hormonal carcinogenesis as well as current treatment options. PREREQ: BISC207, BISC401, CHEM103, CHEM104, CHEM321.

BISC641: Microbial Ecology (3)

- Principles of microbial interactions in natural environments, including applications to industrial microbiology and certain types of pollution. PREREQ: BISC300

BISC645: Bacterial Evolution (3)

- Explores the development of the enormous bacterial diversity beginning with current theories on the origin of life. Examines the evolution of viruses and the "directed evolution" controversy which concerns mechanisms of bacterial evolution. PREREQ: BISC300 or equivalent. TERM: Fall Semester

BISC654: Biochemical Genetics (3)

- Covers the use of genetic model organisms to answer biological questions, including mapping and cloning of human disease genes and the creation of animal models for human genetic diseases. There is an emphasis on examples from the recent scientific literature and building scientific writing skills. PREREQ: BISC403 and BISC401; or permission of instructor

BISC656: Evolutionary Genetics (3)

- Exploration of the theory, methods and experiments underlying current research in evolutionary processes determining genetic variation within and between species, estimation of population structure from genetic data, and the genetics of speciation. PREREQ: BISC403

BISC665: Advanced Molecular Biology & Genetics (3)

- Presents concepts and approaches regarding our current understanding of molecular biology and molecular genetics in eukaryotic organisms. Requires a solid background in biochemistry, cell biology and introductory molecular biology.

BISC671: Cellular and Molecular Immunology (3)

- Introduces the basic concepts of immunology and describes how different immune responses can either protect the body from infection or lead to immunological based diseases. Focuses on cellular interactions and the resultant molecular responses that lead to immune protection. PREREQ: BISC401 or BISC305 or BISC300. Requires permission of instructor. TERM: Fall Semester

BISC675: Cardiovascular Physiology (3)

- Basic physiology of the human cardiovascular system, basis of cardiovascular diseases and current treatments. The focus is on heart failure, hypertension, atherosclerosis, thrombosis and leukemia. PREREQ: A physiology course at or above the 300 level and BISC401 or CHEM527 or CHEM641.

BISC679: Virology (3)

- Molecular biology of animal viruses. Virus structure and organization; mechanisms of penetration, replication, maturation and transformation. PREREQ: BISC401 or biochemistry

BISC682: Bacterial Pathogens: Molecular Mechanisms (3)

- Explore the molecular mechanisms of infectious diseases. Disease transmission and infection, horizontal gene transfer and pathogenomics are reviewed using primary research literature. Topics include water and food borne, airborne, vector borne and human borne pathogens, their molecular mechanisms of invasion, colonization, virulence and immune avoidance.

BISC693: Human Genetics (3)

- Emphasis on the medical and social implications of our knowledge of human genetics. Discusses theoretical and practical principles of genetics useful in studying human variation such as cytogenetics and cell genetics, biochemical genetics, developmental genetics and teratology, principles of genetic counseling, multi-factorial inheritance and the genetics of cancer. PREREQ: BISC403

STAT670: Introduction to Statistical Analysis I (3)

- Basic probability; continuous, discrete and joint distributions; distribution of functions of random variables; order statistics; expected value and central limit theorem.

STAT671: Introduction to Statistical Analysis II (3)

- Distributions of common statistics, sampling techniques, estimation, confidence intervals, hypotheses testing and selected topics.

CHEM624: Principles of Mass Spectrometry (3)

- Principles of mass spectral measurements for the elucidation of molecular structure; applications to biomolecular materials and topics from the current literature. PREREQ: CHEM437

CHEM641: Biochemistry (3)

- Structure and function of proteins, enzymes and coenzymes; kinetics and mechanisms; carbohydrate metabolism and its regulation; and citric acid cycle. PREREQ: CHEM322 or CHEM332. TERM: Fall Semester

CHEM645: Protein Structure and Function (3)

- Overview of structural biology, including how x-ray crystallography, NMR spectroscopy, homology modeling and other techniques are used to solve or model structures of macromolecules. Representative proteins discussed in terms of how a protein's structure relates to its function. PREREQ: CHEM641. TERM: Fall Semester

CHEM646: DNA-Protein Interactions (3)

- Current topics of DNA-protein interactions which focus on DNA replication, DNA recombination, DNA damage repair, transcription and translation processes. PREREQ: CHEM642. TERM: Fall Semester

CHEM649: Molecular Biophysics (3)

- Biophysical principles and methods: thermodynamic and kinetic analysis of folding; protein-nucleic acid interactions; ligand binding; spectroscopy; structural methods; modeling; calorimetry; ultracentrifugation; SPR. Problem solving in macromolecular interactions: protein refolding; altering ligand affinity; increasing protein stability; drug design and HTS; protein expression and solubility; protein engineering. PREREQ: Introductory-level courses in chemistry, physics biochemistry.

ANFS670: Principles of Molecular Genetics (3)

- Fundamentals of nucleic acid biochemistry (replication, repair, and recombination) and bacterial genetics provide the background needed for detailed study of selected topics in animal and plant molecular biology. PREREQ: ANFS300 or permission of instructor.

MAST616: Methods in Molecular Biology (3)

- Conceptual experience in molecular biological techniques with an emphasis on their application to marine related problems. Topics include: nucleic acid extractions, cloning, gene amplification and characterization, and expression methodologies. PREREQ: MAST634

MAST618: Marine Microbial Ecology (3)

- Examines role of microbes in the oceans and their impact on oceanographic processes and biogeochemical cycles in marine environments. Emphasis is on bacteria and their interactions with other marine organisms. Introduces use of molecular tools to examine uncultivated microbes.

MAST623: Physiology of Marine Organisms (3)

- Processes and mechanisms of adaptation of organisms to marine environments. Examines how environmental factors affect physiological processes in marine organisms. Lectures address physiological processes at cellular, whole organism and habitat levels. PREREQ: MAST634 or equivalent. Requires permission of instructor

MAST625: Microbial Physiology and Diversity (3)

- Emphasis on diversity of physiological strategies developed by prokaryotic microbes and some simple eukaryotes. Approach is to examine and dissect specific metabolic pathways both in isolation and in how they integrate with central metabolism. PREREQ: BISC 207/208, CHEM 321 or CHEM 331, or permission of instructor. Juniors, Seniors, and Graduate Students

MAST634: Marine Molecular Sciences (3)

- This course surveys the dominant molecular processes in marine organisms that are essential for survival. Students are introduced to metabolic pathways, protein structure and function, DNA replication and repair, gene transcription and translation, and mitochondiral and chloroplast organelle function. TERM: Fall Semester

PLSC636: Plant Genes and Genomes (3)

- Advanced survey of molecular genetics in higher plants, including molecular methods of plant biotechnology. Topics include genome composition and evolution, transposable elements and retrotransposons, DNA methylation and epigenetics, small RNAs, quantitative traits, chromosome structure and gene expression. PREREQ: PLSC300 and PLSC306.

PLSC644: Physiology of Plant Stress (3)

- Angiosperms' response to biotic and abiotic environmental stresses; mineral nutrients, salt, drought, cold, heat, light, pathogens and herbivores at the physiological and molecular levels. PREREQ: PLSC410.

HESC602: Data Analysis and Interpretation in Health Sciences (3)

- Overview of statistical practice in health sciences research, particularly experimental research. Topics include experimental design, regression, analysis of variance including repeated measures designs and nonparametric tests.

HESC654: Medical Physiology (3)

- Survey of medical physiology, including discussion of major body systems with emphasis on system interaction, homeostasis, and pathophysiology. PREREQ: A previous course in mammalian, applied, cell, or exercise physiology.

PHYT606: Research (3)

- An overview of methodological issues in the conduct of physical therapy research. Topics include scientific method, experimental design, statistical procedures and technical writing. Student expected to critically analyze current physical therapy literature.

PHYT623: Clinical Neuroscience (4)
- A study of the structure and function of the human nervous system with major emphasis on the cause-effect relationships between lesions and their symptoms. Emphasis on the neural mechanisms controlling movement. PREREQ: PHYT622

PHYT633: Applied Physiology II (3)
- Description: Discusses the research on the effects of exercise on the various patient populations (not including cardiopulmonary). Emphasis placed on the musculoskeltal system and on exercise prescription and progression. PREREQ: PHYT632.

PROFESSIONAL SCIENCE MASTER'S PLUS COURSES

G.1. BUSINESS/INDUSTRY TRACK

- **Survey of Business**
  BUAD500: Survey of Business (3)
  - Survey of business principles including business organization and management, market research and marketing, operations management and decision analysis, accounting and financial analysis. Course assignments stress business technical writing and presentation skills.
- **Leadership and Organization**
  BUAD870: Understanding People in Organizations (3)
  - Develops a knowledge base and requisite skills for managing individual, group and organizational processes through the use of diagnostic models, cases and/or experimental experiences.
- **Project Management, Operations or Entrepreneurship**
  BUAD831: Operations Management and Management Science (3)
  - Topics include decision analysis tools, mathematical programming, operations strategy, process management and planning and inventory management concepts. PREREQ: BUAD820 or BUAD500
  BUAD835: Managing New Product Development Projects (3)
  - Examines techniques and issues in project management, with special emphasis on new product development projects. Topics include models for cost estimation, process selection, competitive benchmarking, concurrent engineering, and successful project management. Teams prepare proposal for developing and introducing a new product into the marketplace. PREREQ: BUAD831, BUAD880, FINC850 or BUAD500
  BUAD871: Managing for Creativity and Innovation (3)
  - Focuses on individual characteristics and group and organizational factors that influence the ability of organizations to generate new products and/or processes, and to implement new products/processes. Students practice skills to diagnose barriers and develop creative organizations. PREREQ: BUAD870 or BUAD500

ENTR860: High Technology Entrepreneurship (3)

- Focuses on critical financial, legal, scientific and engineering issues confronted during initial planning stages of a start-up enterprise. Students work in teams to develop a business plan for a real world business product offering.

MISY840: Project Management and Costing (3)

- Provides the technical knowledge and skills needed to successfully plan, execute and evaluate IT projects. Strong emphasis on the costing of IT projects.

- **Intellectual Property**

  CHEG595: Intellectual Property for Engineers and Scientists (3)

  - Methods of protecting intellectual property. Patents, trademarks, copyrights, trade secrets and unfair methods of competition, including analyses of significant court decisions in each area. Directed to innovators in all fields interested in legal protection of their ideas.

G.2. GOVERNMENT/NON-PROFIT TRACK

- **Survey of Public Administration**

  UAPP803: Seminar in Public Administration (3)

  - Reading and discussion of theories and problems of public administration, including organization, coordination, field administration, contracts, personnel, policy making, participation, adjudication, budgeting and administrative behavior.

- **Leadership and Organization**

  UAPP835: Organization and Management in Public and Nonprofit Sectors (3)

  - Explores (1) theories and concepts of organizational phenomena, (2) current challenges and implications for the public and nonprofit sectors, and (3) issues for individuals who work in these organizations. Behavioral competencies are developed.

  UAPP604: Leadership in Organizations (3)

  - Understanding the process of change and positively affecting change in organizations through the exercise of leadership skills and knowledge.

- **Managerial Decision Making or Financial Management**

  UAPP819: Management Decision Making in Public & Nonprofit Sectors (3)

  - Focuses on analytical decision making within public and nonprofit organizations. Examines processes by which decisions can be made and evaluated. Emphasis on conceptual factors that provide a guide to decisions and evaluations of decision methodologies, e.g., systems analysis, cost-benefit analysis, PERT/critical path method, decision trees, performance measurement and time series.

  UAPP833: Financial Management in Public & Nonprofit Sectors (3)

  - Principles of public finance and public sector economics are used to examine issues of demand for and delivery of public goods by state and local governments and nonprofit organizations. Topics include revenues, expenditures, intergovernmental and cross-sectoral relationships, budgeting, debt management and asset allocation. PREREQ: UAPP834

  UAPP827: Program and Project Analysis (3)

  - Explores the ways in which decision-makers in the public sector evaluate the feasibility of government programs and projects through the application of Cost-

Benefit Analysis (CBA), Cost Utility Analysis (CUA), and Cost Effectiveness Analysis (CEA). Focuses on the determination of social costs and social benefits of public policies. PREREQ: UAPP834 or comparable course in public economics and permission of instructor

UAPP829: Taxation and Fiscal Policies (3)

- Advanced course in theory and application of financing, spending and regulatory policy instruments of state and local governments. Topics include efficiency, equity and impacts of different types of taxation, user charges, expenditure approaches (transfers/subsidies) and regulation alternatives.

- **Legal and Regulatory Affairs**

  UAPP646: Administrative Law and Policy (3)

  - Introduces the basic concepts and rules of administrative law and of the legal issues affecting public and nonprofit organizations in dealing with governmental agencies. Special attention placed on the impact politics has on efforts by administrators to comply with administrative law rules and regulations. No prior legal training or command of legal language necessary.

PART II

RESOLUTION STATEMENT

PROVISIONAL APPROVAL OF NEW PROGRAMS -- RESOLUTION

MASTER OF SCIENCE IN BIOINFORMATICS & COMPUTATIONAL BIOLOGY

WHEREAS,

- The program will contribute to the scholarly and educational missions of the University—to *disseminate scientific, humanistic, and social knowledge for the benefit of the larger society* and to produce graduates who *are prepared to contribute to a global society*, addressing *the critical needs of the state, nation and global community*.

- The program will provide a new graduate degree in a discipline essential for University of Delaware as a major research university—there are presently about 100 bioinformatics-related degree programs in the United States.

- The program will foster multi- and interdisciplinary research and educational collaboration across campus, providing a critical component to University's strategic priorities in energy, environment, and life and health sciences, and serving as a pillar of UD's *Path to Prominence*.

- The program will build upon the research strength, education resources and bioinformatics infrastructure from ten participating Departments across the Colleges of Arts & Sciences, Engineering, Agriculture & Natural Resources, and Earth, Ocean & Environment, as well as from the Delaware Biotechnology Institute and the newly established Center for Bioinformatics & Computational Biology.

- The *Master of Science degree* will prepare students for advanced research in bioinformatics and computational biology, playing a key role in multi- and interdisciplinary research teams.

- The *Computational Sciences Concentration* will allow students with strong quantitative sciences background to gain solid knowledge and research experience in developing computational methods and bioinformatics tools and databases for the study of biological systems. The *Life Sciences Concentration* will allow students with strong biological background to gain solid knowledge and research experience in applying bioinformatics methods, tools and databases as an integral approach to life science research.

RESOLVED, that the Faculty Senate approves provisionally, for four years, the establishment of a new program leading to the *M.S. degree in Bioinformatics and Computational Biology*, effective September 1, 2010.

RESOLVED, that the Faculty Senate approves provisionally, for four years, the establishment of a new program entitled *Master of Science in Bioinformatics and Computational Biology (BICB-MS), Computational Sciences Concentration (CS)*, effective September 1, 2010.

RESOLVED, that the Faculty Senate approves provisionally, for four years, the establishment of a new program entitled *Master of Science in Bioinformatics and Computational Biology (BICB-MS), Life Sciences Concentration (LSC)*, effective September 1, 2010.

PROVISIONAL APPROVAL OF NEW PROGRAMS -- RESOLUTION

PROFESSIONAL SCIENCE MASTER'S IN BIOINFORMATICS

WHEREAS,

- The program will contribute to the scholarly and educational missions of the University—to *disseminate scientific, humanistic, and social knowledge for the benefit of the larger society* and to produce graduates who *are prepared to contribute to a global society*, addressing *the critical needs of the state, nation and global community*.

- The program will provide a new graduate degree in a discipline essential for University of Delaware as a major research university and position UD as a regional leader in bioinformatics professional education.

- The program will foster multi- and interdisciplinary research and educational collaboration across campus, providing a critical component to University's strategic priorities in energy, environment, and life and health sciences, and serving as a pillar of UD's *Path to Prominence*.

- The program will build upon the research strength, education resources and bioinformatics infrastructure from ten participating Departments across the Colleges of Arts & Sciences, Engineering, Agriculture & Natural Resources, and Earth, Ocean & Environment, as well as from the Delaware Biotechnology Institute and the newly established Center for Bioinformatics & Computational Biology.

- The *Professional Science Master's degree* will well prepare students for a bioinformatics professional career in industry, business, government agencies, or non-profit organizations, playing a key role in multi- and interdisciplinary teams.

- The *Computational Sciences Concentration* will allow students to gain solid knowledge and industry experience in developing bioinformatics methods, tools and/or databases for modern biotechnology or medicine. The *Life Sciences Concentration* will allow students to gain solid knowledge and industry experience in applying bioinformatics methods, tools and databases as an integral approach to modern biotechnology and medicine.

RESOLVED, that the Faculty Senate approves provisionally, for four years, the establishment of a new program leading to the *P.S.M. degree in Bioinformatics*, effective September 1, 2010.

RESOLVED, that the Faculty Senate approves provisionally, for four years, the establishment of a new program entitled *Professional Science Master's in Bioinformatics (BINF-PSM), Computational Sciences Concentration (CS1)*, effective September 1, 2010.

RESOLVED, that the Faculty Senate approves provisionally, for four years, the establishment of a new program entitled *Professional Science Master's in Bioinformatics (BINF-PSM), Life Sciences Concentration (LSC1)*, effective September 1, 2010.

PROVISIONAL APPROVAL OF NEW PROGRAMS -- RESOLUTION

GRADUATE CERTIFICATE IN BIOINFORMATICS

WHEREAS,

- The program will contribute to the scholarly and educational missions of the University—to *disseminate scientific, humanistic, and social knowledge for the benefit of the larger society* and to produce graduates who *are prepared to contribute to a global society*, addressing *the critical needs of the state, nation and global community*.

- The program will provide a new graduate certificate in a discipline essential for University of Delaware as a major research university—there are presently about 100 bioinformatics-related degree programs in the United States.

- The program will foster multi- and interdisciplinary research and educational collaboration across campus, providing a critical component to University's strategic priorities in energy, environment, and life and health sciences, and serving as a pillar of UD's *Path to Prominence*.

- The program will build upon the research strength, education resources and bioinformatics infrastructure from ten participating Departments across the Colleges of Arts & Sciences, Engineering, Agriculture & Natural Resources, and Earth, Ocean & Environment, as well as from the Delaware Biotechnology Institute and the newly established Center for Bioinformatics & Computational Biology.

- The *Graduate Certificate* will provide bioinformatics core competency, ideally suited for working professionals as a stepping stone and for current graduate students at UD to gain bioinformatics skills.

- The *Computational Sciences Concentration* will allow students to gain knowledge and skills in developing bioinformatics methods, tools and/or databases for modern biotechnology or medicine. The *Life Sciences Concentration* will allow students to gain knowledge and skills in applying bioinformatics methods, tools and databases as an integral approach to modern biotechnology or medicine.

RESOLVED, that the Faculty Senate approves provisionally, for four years, the establishment of a new program leading to the *Graduate Certificate in Bioinformatics*, effective September 1, 2010.

RESOLVED, that the Faculty Senate approves provisionally, for four years, the establishment of a new program entitled *Graduate Certificate in Bioinformatics (BINF-CERT), Computational Sciences Concentration (CS2)*, effective September 1, 2010.

RESOLVED, that the Faculty Senate approves provisionally, for four years, the establishment of a new program entitled *Graduate Certificate in Bioinformatics (BINF-CERT), Life Sciences Concentration (LSC2)*, effective September 1, 2010.

PART III

GRADUATE CATALOG LISTING

BIOINFORMATICS & COMPUTATIONAL BIOLOGY

Telephone: (302) 831-0161
http://bioinformatics.udel.edu/Education
Faculty Listing: http://bioinformatics.udel.edu/Education/faculty

A. PROGRAM OVERVIEW

Bioinformatics & Computational Biology is an emerging field where biological and computational disciplines converge. The field encompasses the development and application of computational tools and techniques for the collection, analysis, management, and visualization of biological data, as well as modeling and simulation methods for the study of biological systems. Essential to the 21st century life sciences research and key to our understanding of complex biological systems, Bioinformatics & Computational Biology is impacting the science and technology of fields ranging from agricultural, energy and environmental sciences to pharmaceutical and medical sciences.

The Master's program in Bioinformatics & Computational Biology is administered through the Department of Computer & Information Sciences and coordinated by the Center for Bioinformatics & Computational Biology. The scientific curriculum is supported with the research strength, education resources and bioinformatics infrastructure from ten participating Departments across the Colleges of Arts & Sciences, Engineering, Agriculture & Natural Resources, and Earth, Ocean & Environment, as well as the Delaware Biotechnology Institute.

The Master's program offers three degrees—Master of Science in Bioinformatics & Computational Biology (BICB-MS), Professional Science Master's in Bioinformatics (BINF-PSM), and Graduate Certificate in Bioinformatics (BINF-CERT), each with two concentrations—Computational Sciences Concentration and Life Sciences Concentration. The Computational Sciences Concentration provides knowledge and experience in developing computational methods and bioinformatics tools and databases for modern biological studies, biotechnology or medicine. The Life Sciences Concentration provides knowledge and experience in applying bioinformatics methods, tools and databases as an integral approach to life science research, modern biotechnology or medicine.

Graduates of the Master's program will play a key role in multi- and interdisciplinary teams, bridging life sciences and computational sciences. The thesis-based MS degree will prepare students for advanced research in bioinformatics and computational biology. The scientific curriculum, along with "Plus" component for professional skills and the immersive internship will prepare PSM graduates for a professional career in industry or government. The Certificate will provide bioinformatics core competency as a stepping stone for a professional career.

B. REQUIREMENTS FOR ADMISSION

Admission to the graduate program is competitive. Those who meet stated requirements are not guaranteed admission, nor are those who fail to meet all of those requirements necessarily precluded from admission if they offer other appropriate strengths.

The following are the admission requirements to the Master's program in Bioinformatics & Computational Biology that apply to all three degrees (BICB-MS, BINF-PSM and BINF-CERT):

- A bachelor's degree at an accredited four-year college or university with a minimum grade average of 3.0 on a 4.0 system;
- Applicants may have undergraduate degrees from biological, computational, or other disciplines. However, applicants are expected to have scholarly competence in mathematics, computer science and/or biology;
- The following GRE scores are competitive: Quantitative: 650, Verbal + Quantitative: 1200. No GRE subject test is required;
- International student applicants must demonstrate a satisfactory level of proficiency in the English language if English is not the first language. The University requires an official paper-based TOEFL score of at least 550, at least 213 on the computer-based TOEFL, or at least 79 on the Internet-based TOEFL. TOEFL scores more than two years old cannot be considered official;
- Three letters of recommendation are required. At lease one letter must be from professors, other letters can be from employers or others who have had a supervisory relationship with the applicant and are able to assess the applicant's potential for success in graduate studies; and
- Applications must also include a resume outlining work and academic experience, as well as an application essay consisting of the answers to the following questions:
  1. What educational background and scientific research or employment experience prepare you for this bioinformatics degree program?
  2. What are your long-term professional objectives?
  3. What specific attributes of the bioinformatics program make you feel that this degree is appropriate to help you achieve your professional objectives?

C. OVERVIEW OF DEGREE REQUIREMENTS

The Table below summarizes the degrees offered in the Master's program in Bioinformatics & Computational Biology and their curriculum requirements:

- Science Core in Bioinformatics & Computational Biology
  - Computational Sciences (CS)
  - Life Science (LS)
- Ethics Core
- Science Electives in Bioinformatics & Computational Biology
  - Computational Sciences (CS)
  - Life Science (LS)
- Thesis/Seminar/Internship in Bioinformatics & Computational Biology
- Professional Science Master's Plus Courses
  - Business/Industry Track (BI)
  - Government/Non-Profit Track (GN)

Curriculum/Credits	Degrees Offered*					
	BICB-MS (CS)	BICB-MS (LSC)	BINF-PSM (CS1)	BINF-PSM (LSC1)	BINF-CERT (CS2)	BINF-CERT (LSC2)
Science Core-CS	15		15		15	
Science Core-LS		15		15		15
Ethics Core	3	3	3	3		
Science Electives-CS	6		6			
Science Electives-LS		6		6		
Thesis	6	6				
Seminar	3	3				
Internship			6	6		
PSM Plus – BI or GN			12	12		
Total Credits	33	33	42	42	15	15

BICB-MS (CS): Master of Science in Bioinformatics & Computational Biology, Computational Sciences Concentration
BICB-MS (LSC): Master of Science in Bioinformatics & Computational Biology, Life Sciences Concentration
BINF-PSM (CS1): Professional Science Master's in Bioinformatics, Computational Sciences Concentration
BINF-PSM (LSC1): Professional Science Master's in Bioinformatics, Life Sciences Concentration
BINF-CERT (CS2): Graduate Certificate in Bioinformatics, Computational Sciences Concentration
BINF-CERT (LSC2): Graduate Certificate in Bioinformatics, Life Sciences Concentration

D. REQUIREMENTS FOR MASTER OF SCIENCE IN BIOINFORMATICS & COMPUTATIONAL BIOLOGY (BICB-MS)

The **Master of Sciences in Bioinformatics & Computational Biology** requires 24 credits of graduate-level coursework, 6 credits of thesis and 3 credits of seminar, totaling 33 credits. The 24 credits of coursework must include 15 credits in the Bioinformatics & Computational Biology Core courses and 3 credits in the Ethics Core courses. Attendance in Seminar (BINF865) is required for three semesters for all graduate students.

A Thesis (BINF869) is required for the MS degree. Unless special permission is granted, students need to complete 12 credit hours prior to the start of their thesis. Students, with the assistance of their Faculty Advisor, will prepare and present a research proposal to their Thesis Committee for review and approval of the proposed research project. Following completion of the research outlined in the proposal, the MS degree candidate will prepare a written thesis according to the guidelines set forth by the Office of Graduate and Professional Education. A thesis defense, preceded by a seminar, will be held. The student's Faculty Advisor and Thesis Committee will administer and evaluate the thesis defense.

BICB-MS: COMPUTATIONAL SCIENCES CONCENTRATION
Credit Requirements:
A. Bioinformatics & Computational Biology Core–Computational Science…………... 15 Credits
B. Ethics Core ……………………………………………………………………… 3 Credits
C. Electives–Computational Sciences …………………………………………….... 6 Credits
D. Thesis …………………………………………………………………………… 6 Credits
E. Seminar ………………………………………………………………………….. 3 Credits

Total number of required credits: 33

A. Bioinformatics & Computational Biology Core–Computational Science (15 credits)
Bioinformatics
CISC636 Bioinformatics ……………………………………………………………................ 3
Introduction to Discipline (select one)
ELEG 671 Introduction to Biomedical Engineering …………………………………….…… 3
BISC 602 Molecular Biology of Animal Cells …………………………...…………………3
BISC 612 Advanced Cell Biology……………………………………………………….…… 3
BISC 654 Biochemical Genetics…………………………………………………….………… 3
PLSC 636 Plant Genes and Genomes………………………………………….……..……….. 3
ANFS 670 Principles of Molecular Genetics…………………………………………………3
MAST 616 Methods in Molecular Biology…………………………………………..…….… 3
Systems Biology
MATH 560 Introduction to Systems Biology……………………………………………….… 3
Database
CISC 637 Database Systems……………………………………………………………….… 3
Biostatistics (select one)
STAT 613 Multivariate Statistical Methods with Biology Applications…………..………..….… 3
STAT 656 Biostatistics……………………………………………………………….…… 3

B. Ethics Core (3 credits)
Ethics (select one)
BIOL 631 Practice of Science…………………………………………………...……….…… 3
UAPP 648 Environmental Ethics……………………………………………………….…..… 3
UAPP 650 Values Ethics and Leadership………………………………………..….……… 3
BUAD 840 Ethical Issues in Global Business Environments…………………….…..…….… 3

C. Electives–Computational Sciences (6 credits)
Electives (select two)
CISC 841 Algorithms in Bioinformatics …………………………………………………... 3
CISC 621 Algorithm Design and Analysis ……………………………………....…..……….3
CISC 640 Computer Graphics ……………………………………………………………... 3
CISC 642 Introduction to Computer Vision …….…………………………………..…….…...3
CISC 650 Computer Networks ……………………………………………………….…..… 3
CISC 675 Object Oriented Software Engineering ……………………………..…….………… 3
CISC 681 Artificial Intelligence ……………………………………………...…..…………… 3
CISC 683 Introduction to Data mining ………………………………………………….…… 3
CISC 882 Natural Language Processing ……………………………………………..…….…… 3
CISC 886 Multi-Agent Systems ……………………………………………..….…………...3
CISC 887 Internet Information Gathering …………………………………….…….………… 3
CISC 888 Machine Learning ………………………………………………….…..………… 3
MATH 607 Survey of Scientific Computing ………………………………………..………… 3
MATH 611 Introduction to Numerical Analysis and Scientific Computing ……………….……3
STAT 670 Introduction to Statistical Analysis I ……………………………...….……………3
STAT 671 Introduction to Statistical Analysis II ……………………………………..……….. 3
STAT 608 Statistical Research Methods ………………………………………..….………... 3

STAT 615 Design and Analysis of Experiments …………………………………..……………3
STAT 619 Time Series Analysis …………………………………………………………..……… 3
STAT 621 Survival Analysis …………………………………………………………..….……… 3
STAT 674 Applied Data Base Management…………………………………………….……….. 3
ELEG 633 Image Processing ……………………………………………………………….……… 3
ELEG 652 Principles of Parallel Computer Architectures ………………………….…………… 3
ELEG 655 High-Performance Computing with Commodity Hardware …………….…………… 3
ELEG 679 Introduction to Medical Imaging Systems …………………………………….……… 3
ELEG 680 Immunology for Engineers ……………………………………………………….…… 3
CHEG 620 Biochemical Engineering ……………………………………………………….…… 3
CHEG 621 Metabolic Engineering ………………………………………………………..……….3

D. Thesis (6 credits)
BINF 869 Master's Thesis…………………………………………………………..........… 1-6

E. Seminar in Bioinformatics & Computational Biology (3 credits)
Seminar (3 Semesters)
BINF 865 Seminar ……………..…………………..…………………………………...….…... 1

BICB-MS: LIFE SCIENCES CONCENTRATION

Credit Requirements:
A. Bioinformatics & Computational Biology Core–Life Science…………..………...15 Credits
B. Ethics Core ………………………………………………………………………… 3 Credits
C. Electives–Life Sciences …………………………………………………………... 6 Credits
D. Thesis …………………………………………………………………………… 6 Credits
E. Seminar …………………………………………………………………………….. 3 Credits
Total number of required credits: 33

A. Bioinformatics & Computational Biology Core–Life Science (15 credits)
Bioinformatics
ANFS 644 Bioinformatics ……………………………………………………………...............3
Introduction to Discipline
MAST 697 Bioinformatics Programming for Biologists ………………………………..……… 3
Systems Biology
MAST 698 Environmental and Systems Bioinformatics ……………………………………… 3
Database
CISC 637 Database Systems…………………………………………………………….……… 3
Biostatistics (select one)
STAT 613 Multivariate Statistical Methods with Biology Applications…………..………..…… 3
STAT 656 Biostatistics…………………………………………………………………….…… 3

B. Ethics Core (3 credits)
Ethics (select one)
BIOL 631 Practice of Science………………………………………………..……….…… 3
UAPP 648 Environmental Ethics…………………………………………………….….…… 3
UAPP 650 Values Ethics and Leadership…………………………..……………...…………… 3

BUAD 840 Ethical Issues in Global Business Environments………………………….…………. 3

C. Electives–Life Sciences (6 credits)
Electives (select two)
BISC 600 Biotechnology and Molecular Medicine …………………….……….……………3
BISC 602 Molecular Biology of Animal Cells …………………..……………..……………. 3
BISC 605 Advanced mammalian physiology ……………….……..……………..……………. 3
BISC 612 Advanced Cell Biology …………….…………………..………….……………. 3
BISC 615 Vertebrate Developmental Biology…………………………………….……………3
BICS 625 Cancer Biology ………………….……..………………………….……..…………. 3
BISC 641 Microbial Ecology …………….…………………………….………..……………. 3
BISC 645 Bacterial Evolution …………….…………………………………….……………. 3
BISC 654 Biochemical Genetics …………….…………………………………….……………. 3
BISC 656 Evolutionary Genetics …………….………………………………….……………. 3
BISC 665 Advanced Molecular Biology & Genetics ………………………….…..…………. 3
BISC 671 Cellular and Molecular Immunology …………….…………………….……………. 3
BISC 675 Cardiovascular Physiology …………….……………………………….…………... 3
BISC 679 Virology …………….……………………………………….……………………. 3
BISC 682 Bacterial Pathogens Molecular Mechanisms ………………………….……………. 3
BISC 693 Human Genetics …………….…………………………………….……………. 3
STAT 670 Introduction to Statistical Analysis I …………….…………………..….…………. 3
STAT 671 Introduction to Statistical Analysis II …………….……………………..…………. 3
CHEM 624 Principles of Mass Spectrometry …………….…………………..….……………. 3
CHEM 641 Biochemistry …………….…………………………………….……………... 3
CHEM 645 Protein Structure and Function …………….…………………….………………... 3
CHEM 646 DNA-Protein Interactions …………….………………………….……………. 3
CHEM 649 Molecular Biophysics …………….………………………………….……………. 3
ANFS 670 Principles of Molecular Genetics …………….………………………….…………. 3
MAST 616 Methods in Molecular Biology …………….……………………..….……………... 3
MAST 618 Marine Microbial Ecology …………….………………………..….……………. 3
MAST 623 Physiology of Marine Organisms …………….………………………..….………... 3
MAST 625 Microbial Physiology and Diversity …………….………………………..….……... 3
MAST 634 Marine Molecular Sciences …………….……………………………….………. 3
PLSC 636 Plant Genes and Genomes …………….……………………………………… 3
PLSC 644 Physiology of Plant Stress …………….…………………………..……………. 3
PLSC 667 Analytical Plant Genetics …………….…………………………………….……. 3
HESC 602 Data Analysis and Interpretation in Health Sciences ………………….……………. 3
HESC 654 Medical Physiology …………….…………………………………….……………. 3
PHYT 606 Research………………………………..…………………………….……………... 3
PHYT 623 Clinical Neuroscience……………………………………………….…..…….……... 4
PHYT 633 Applied Physiology II …………….……………………………………….…….…...3

D. Thesis (6 credits)
BINF 869 Master's Thesis……………………………………………………………….......… 1-6

E. Seminar in Bioinformatics & Computational Biology (3 credits)
Seminar (3 Semesters)
BINF 865 Seminar …………..……………………….…………………………………..….…..1

E. REQUIREMENTS FOR PROFESSIONAL SCIENCE MASTER'S IN BIOINFORMATICS (BINF-PSM)

The **Professional Science Master's in Bioinformatics** requires 24 credits of graduate-level coursework, 6 credits of internship and 12 credits of PSM PLUS coursework, totaling 42 credits. The 24 credits of coursework must include 15 credits in the Bioinformatics & Computational Biology Core courses and 3 credits in the Ethics Core courses.

An Internship (BINF864) is required for the PSM degree. The internship will be in most cases completed at participating companies/institutions in the BINF-PSM program and be jointly supervised by the Faculty Advisor and a Co-Mentor in the hosting institution. Unless special permission is granted, students need to complete 12 credit hours prior to the start of their internship. The participating mentors will develop with the internship student specific objectives to be met during the internship, and have the internship approved by the Director of the Master's BINF-PSM program prior to the start of the internship. A final written report and a poster presentation are required to complete the course.

The PSM degree requires at least 12 credits of PLUS coursework in addition to their science core. Whereas students in the PSM program may have professional goals that would lead them into business and industry or to government or non-profit employment, the University of Delaware offers two tracks for the PSM PLUS component. The University recommends the student follow one of the PLUS tracks below, however students may cross over tracks to fit their interest.

BINF-PSM: COMPUTATIONAL SCIENCES CONCENTRATION

Credit Requirements:
A. Bioinformatics & Computational Biology Core–Computational Science…………….. 15 Credits
B. Ethics Core …………………………………………………………………………… 3 Credits
C. Electives–Computational Sciences …………………………………………………... 6 Credits
D. Internship ………………………………………………………………………….… 6 Credits
E. PSM Plus courses……………………………………………………………….……12 Credits
Total number of required credits: 42

A. Bioinformatics & Computational Biology Core–Computational Science (15 credits)
Bioinformatics
CISC636 Bioinformatics …………………………………………………………................ 3
Introduction to Discipline (select one)
ELEG 671 Introduction to Biomedical Engineering …………………………………..…… 3
BISC 602 Molecular Biology of Animal Cells …………………………...…………………3
BISC 612 Advanced Cell Biology…………………………………………………...……… 3
BISC 654 Biochemical Genetics………………………………………………….…..…… 3
PLSC 636 Plant Genes and Genomes…………………………………………….….…..   3
ANFS 670 Principles of Molecular Genetics…………………………………………..…… 3
MAST 616 Methods in Molecular Biology…………………………………………….…..… 3
Systems Biology

MATH 560 Introduction to Systems Biology…………………………………………………… 3
Database
CISC 637 Database Systems……………………………………………………….…..… 3
Biostatistics (select one)
STAT 613 Multivariate Statistical Methods with Biology Applications………………..…… 3
STAT 656 Biostatistics……………………………………………………………… 3

B. Ethics Core (3 credits)
Ethics (select one)
BIOL 631 Practice of Science……………………………………………..…………… 3
UAPP 648 Environmental Ethics…………………………………………….…..……… 3
UAPP 650 Values Ethics and Leadership……………………….……………..…..……… 3
BUAD 840 Ethical Issues in Global Business Environments…………………….…..……… 3

C. Electives–Computational Sciences (6 credits)
Electives (select two)
CISC 841 Algorithms in Bioinformatics …………………………………………….... 3
CISC 621 Algorithm Design and Analysis ……………………………………..…….…… 3
CISC 640 Computer Graphics ………………………………………………………... 3
CISC 642 Introduction to Computer Vision ….……………………………………….... 3
CISC 650 Computer Networks ……………………………………………………..…3
CISC 675 Object Oriented Software Engineering …………………………..…………… 3
CISC 681 Artificial Intelligence ……………………………….…..…………………… 3
CISC 683 Introduction to Data mining ……………………………………………..…… 3
CISC 882 Natural Language Processing ……………………………………….…..……… 3
CISC 886 Multi-Agent Systems …………………………………………..…..………… 3
CISC 887 Internet Information Gathering ………………………………..…..………… 3
CISC 888 Machine Learning ……………………………………………..…..………… 3
MATH 607 Survey of Scientific Computing …………………………..…..…………… 3
MATH 611 Introduction to Numerical Analysis and Scientific Computing …………………… 3
STAT 670 Introduction to Statistical Analysis I …………………………..…..………… 3
STAT 671 Introduction to Statistical Analysis II …………………………..…..……….. 3
STAT 608 Statistical Research Methods …………………………………..…..……….. 3
STAT 615 Design and Analysis of Experiments ……………………………..………… 3
STAT 619 Time Series Analysis ……………………………………………..…..……… 3
STAT 621 Survival Analysis …………………………………………..…..…………… 3
STAT 674 Applied Data Base Management……………………………………………….. 3
ELEG 633 Image Processing …………………………………………………..…..……… 3
ELEG 652 Principles of Parallel Computer Architectures …………………………………… 3
ELEG 655 High-Performance Computing with Commodity Hardware …………………….… 3
ELEG 679 Introduction to Medical Imaging Systems …………………………………… 3
ELEG 680 Immunology for Engineers ……………………………………………..…..…3
CHEG 620 Biochemical Engineering …………………………………………………… 3
CHEG 621 Metabolic Engineering …………………………………………..…..……… 3

D. Internship (6 credits)
BINF 864 Internship………………………………………..……………………........… 1-6

E. PSM Plus courses (12 credits)
Business/Industry Track
Survey of Business
BUAD 500 Survey of Business …………………………………………………..……….. 3
Leadership and Organization
BUAD 870 Understanding People in Organizations …………………………………………. 3
Project Management, Operations or Entrepreneurship (select one)
BUAD 831 Operations Management and Management Science ……………………………….. 3
BUAD 835 Managing New Product Development Projects ………………………………….. 3
BUAD 871 Managing for Creativity and Innovation ……………………………………….….. 3
ENTR 860 High Technology Entrepreneurship ………………………………………….... 3
MISY 840 Project Management and Costing ……………………………………………….. 3
Intellectual Property
CHEG 595 Intellectual Property for Engineers and Scientists …………………………..…….. 3

Or Government/Non-Profit Track
Survey of Public Administration
UAPP 803 Seminar in Public Administration ………………………….…………………..…….. 3
Leadership and Organization (select one)
UAPP 835 Organization and Management in Public and Nonprofit Sectors ……………...…….. 3
UAPP 604 Leadership in Organizations …………………………………………………..…..…..3
Managerial Decision Making or Financial Management (select one)
UAPP 819 Management Decision Making in Public & Nonprofit Sectors ……………….…..….. 3
UAPP 833 Financial Management in Public & Nonprofit Sectors ………………...…..…….. 3
UAPP 827 Program and Project Analysis ……………………………………………..…….. 3
UAPP 829 Taxation and Fiscal Policies …………………………………………….…..…..…..3
Legal and Regulatory Affairs
UAPP 646 Administrative Law and Policy …………………………………………………… 3

BINF-PSM: Life Sciences Concentration

Credit Requirements:
A. Bioinformatics & Computational Biology Core–Life Science……………..………....15 Credits
B. Ethics Core …………………………………………………………………………… 3 Credits
C. Electives–Life Sciences ……………………………………………….……………... 6 Credits
D. Internship ………………………………………………………………………...… 6 Credits
E. PSM Plus courses………………………………………………………………..…12 Credits
Total number of required credits: 42

A. Bioinformatics & Computational Biology Core–Life Science (15 credits)
Bioinformatics
ANFS 644 Bioinformatics …………………………………………………………...............3
Introduction to Discipline
MAST 697 Bioinformatics Programming for Biologists ……………………………...…. 3
Systems Biology
MAST 698 Environmental and Systems Bioinformatics ………………….………………… 3

Database
CISC 637 Database Systems………………………………….……… 3
Biostatistics (select one)
STAT 613 Multivariate Statistical Methods with Biology Applications…………….………..…… 3
STAT 656 Biostatistics…………………………………………………….…… 3

B. Ethics Core (3 credits)
Ethics (select one)
BIOL 631 Practice of Science………………………………………………..…………… 3
UAPP 648 Environmental Ethics……………………………………………………….…… 3
UAPP 650 Values Ethics and Leadership………………………………………..…………… 3
BUAD 840 Ethical Issues in Global Business Environments…………………………..………… 3

C. Electives–Life Sciences (6 credits)
Electives (select two)
BISC 600 Biotechnology and Molecular Medicine …………………..……………………………3
BISC 602 Molecular Biology of Animal Cells …………………..……………………….. 3
BISC 605 Advanced mammalian physiology ……………………..………………….…….. 3
BISC 612 Advanced Cell Biology …………………..……………………………………….. 3
BISC 615 Vertebrate Developmental Biology…………………..…………………….………….. 3
BICS 625 Cancer Biology …………………..………………………………..…………….. 3
BISC 641 Microbial Ecology …………………………………………………………….. 3
BISC 645 Bacterial Evolution ……………………..………………………………………….. 3
BISC 654 Biochemical Genetics ……………………..…………………………………….. 3
BISC 656 Evolutionary Genetics ………………………………………………….……….. 3
BISC 665 Advanced Molecular Biology & Genetics …………………………………..……… 3
BISC 671 Cellular and Molecular Immunology …………………..…………………………. 3
BISC 675 Cardiovascular Physiology ……………………………………………….……..… 3
BISC 679 Virology …………………………………………………………………………… 3
BISC 682 Bacterial Pathogens Molecular Mechanisms …………………………………………. 3
BISC 693 Human Genetics ………………………..…………………………….…………….. 3
STAT 670 Introduction to Statistical Analysis I ………………..………………..…………….. 3
STAT 671 Introduction to Statistical Analysis II ………………..………………………….. 3
CHEM 624 Principles of Mass Spectrometry …………………..………..………..………….. 3
CHEM 641 Biochemistry ……………………..……………………………………………. 3
CHEM 645 Protein Structure and Function ……………………..……………….……….. 3
CHEM 646 DNA-Protein Interactions ……………………..……………….…………….. 3
CHEM 649 Molecular Biophysics ……………………..…………………………………. 3
ANFS 670 Principles of Molecular Genetics ……………………………………………….. 3
MAST 616 Methods in Molecular Biology ……………………..………………………….. 3
MAST 618 Marine Microbial Ecology ………………………………………….………….. 3
MAST 623 Physiology of Marine Organisms ………………………………………………….. 3
MAST 625 Microbial Physiology and Diversity ……………………..…………………….. 3
MAST 634 Marine Molecular Sciences ……………………..………………………….. 3
PLSC 636 Plant Genes and Genomes ………………………..…………………………. 3
PLSC 644 Physiology of Plant Stress ……………………..……………………………. 3
PLSC 667 Analytical Plant Genetics ……………………..……………..……………….. 3
HESC 602 Data Analysis and Interpretation in Health Sciences ……………..….………… 3

HESC 654 Medical Physiology …………………………………………………..……… 3
PHYT 606 Research………………………………………………………………...……... 3
PHYT 623 Clinical Neuroscience…………………………………………….…..……… 4
PHYT 633 Applied Physiology II …………………………….………………...……...3

D. Internship (6 credits)
BINF 864 Internship………………………………………………………….........… 1-6

E. PSM Plus courses (12 credits)
Business/Industry Track
Survey of Business
BUAD 500 Survey of Business …………………………………………………...…….. 3
Leadership and Organization
BUAD 870 Understanding People in Organizations …………………………………….. 3
Project Management, Operations or Entrepreneurship (select one)
BUAD 831 Operations Management and Management Science ……………………….….. 3
BUAD 835 Managing New Product Development Projects ………………………………. 3
BUAD 871 Managing for Creativity and Innovation …………………………………..….. 3
ENTR 860 High Technology Entrepreneurship ……………………………………….....3
MISY 840 Project Management and Costing ……………………………………………. 3
Intellectual Property
CHEG 595 Intellectual Property for Engineers and Scientists ………………………...…….. 3

Or Government/Non-Profit Track
Survey of Public Administration
UAPP 803 Seminar in Public Administration ………………………………………..…….. 3
Leadership and Organization (select one)
UAPP 835 Organization and Management in Public and Nonprofit Sectors ………….......…..3
UAPP 604 Leadership in Organizations ……………………………………………..……..3
Managerial Decision Making or Financial Management (select one)
UAPP 819 Management Decision Making in Public & Nonprofit Sectors ………….…..…... 3
UAPP 833 Financial Management in Public & Nonprofit Sectors ………………....……….. 3
UAPP 827 Program and Project Analysis ………………………………………......…….. 3
UAPP 829 Taxation and Fiscal Policies ………………………………………..……...…..3
Legal and Regulatory Affairs
UAPP 646 Administrative Law and Policy …………………………………………… 3

F. REQUIREMENTS FOR GRADUATE CERTIFICATE IN BIOINFORMATICS (BINF-CERT)

The **Graduate Certificate in Bioinformatics** requires 15 credits in the Bioinformatics & Computational Biology Core courses to achieve core competency in Bioinformatics.

BINF-CERT: COMPUTATIONAL SCIENCES CONCENTRATION

Credit Requirements:

Bioinformatics & Computational Biology Core–Computational Science………….…... 15 Credits
Total number of required credits: 15

Bioinformatics & Computational Biology Core–Computational Science (15 credits)

Bioinformatics
CISC636 Bioinformatics …………………………………………………………................. 3
Introduction to Discipline (select one)
ELEG 671 Introduction to Biomedical Engineering …………………………………..…… 3
BISC 602 Molecular Biology of Animal Cells …………………………...………………….3
BISC 612 Advanced Cell Biology…………………………………………………..…… 3
BISC 654 Biochemical Genetics…………………………………………………….…..… 3
PLSC 636 Plant Genes and Genomes…………………………………………………..…….. 3
ANFS 670 Principles of Molecular Genetics…………………………………………..…… 3
MAST 616 Methods in Molecular Biology……………………………………….…..…… 3
Systems Biology
MATH 560 Introduction to Systems Biology………………………………………….…… 3
Database
CISC 637 Database Systems……………………………………………………….….…… 3
Biostatistics (select one)
STAT 613 Multivariate Statistical Methods with Biology Applications………….………..…… 3
STAT 656 Biostatistics……………………………………………………………….…..… 3

BINF-CERT: LIFE SCIENCES CONCENTRATION

Credit Requirements:
Bioinformatics & Computational Biology Core–Life Science…………..…….……...15 Credits
Total number of required credits: 15

Bioinformatics & Computational Biology Core–Life Science (15 credits)

Bioinformatics
ANFS 644 Bioinformatics …………………………………………………………...............3
Introduction to Discipline
MAST 697 Bioinformatics Programming for Biologists ……………………………..……… 3
Systems Biology
MAST 698 Environmental and Systems Bioinformatics ……………..……………………..… 3
Database
CISC 637 Database Systems…………………………………………………………...….…… 3
Biostatistics (select one)
STAT 613 Multivariate Statistical Methods with Biology Applications………….………..…… 3
STAT 656 Biostatistics……………………………………………………………….…..… 3

PART IV

PROPOSAL

I. DESCRIPTION

The completion of the human genome sequence marked the beginning of a new era of biological research. Scientists have begun to systematically tackle gene functions and other complex regulatory processes by studying organisms at the global scales. Advances in high-throughput biotechnologies and large-scale bioscience have further enabled modeling and simulation over a multitude of length, time and biological scales from biomolecules, cells, tissues and organs to organisms and population. With the enormous volume of data being produced, biology is becoming an increasingly quantitative science. Computational approaches, in combination with experimental methods, have become essential for generating novel hypotheses, deriving new scientific knowledge, and driving discovery and innovation.

Bioinformatics & Computational Biology is an emerging field where biological and computational disciplines converge. According to the National Institutes of Health, the working definitions of Bioinformatics and Computational Biology are as follows:

- *Bioinformatics*: Research, development, or application of computational tools and approaches for expanding the use of biological, medical, behavioral or health data, including those to acquire, store, organize, archive, analyze, or visualize such data.
- *Computational Biology*: The development and application of data-analytical and theoretical methods, mathematical modeling and computational simulation techniques to the study of biological, behavioral, and social systems.

Fundamental to the modern day biological studies and key to the basic understanding of complex biological systems, Bioinformatics & Computational Biology is impacting the science and technology of fields ranging from agricultural and environmental sciences to pharmaceutical and medical sciences. The research requires close collaboration among multi-disciplinary teams of researchers in quantitative sciences, life sciences, and their interfaces.

We propose to offer three degrees in the Master's program in Bioinformatics & Computational Biology—*Master of Science in Bioinformatics & Computational Biology (BICB-MS), Professional Science Master's in Bioinformatics (BINF-PSM),* and *Graduate Certificate in Bioinformatics (BINF-CERT).* We propose that all three degree programs will have two concentrations—*Computational Sciences Concentration (CS, CS1, CS2)* and *Life Sciences Concentration (LSC, LSC1, LSC2).* The three degree programs will share the common Bioinformatics & Computational Biology Core (15 credits). The Master of Science (MS) and the Professional Science Master's (PSM) will also share the same Elective courses (6 credits) and Ethic courses (3 credits). The Thesis (6 credits) and Seminars (3 credits) of BICB-MS will prepare students for advanced research, while the immersive Internship of BINF-PSM (6 credits) will provide hands-on real-world experience in research and development. In addition, the BINF-PSM will have a "Plus" component (12 credits) to provide training for professional skills. Launching the Master's program in Bioinformatics & Computational Biology with three degrees and two concentrations at the same time (Fall 2010) will support students from different educational backgrounds and with different career aspirations, while leveraging the common course curriculum.

The Master's program in Bioinformatics & Computational Biology aims to train the next-generation of researchers and professionals who will play a key role in multi- and interdisciplinary teams, bridging life sciences and computational sciences. The program will be administered through its academic home, the Department of Computer & Information Sciences, and will be coordinated by the newly established Center for Bioinformatics & Computational Biology. The scientific curriculum will build upon the research and educational strength from departments across the Colleges of Arts & Sciences, Engineering, Agriculture & Natural Resources, and Earth, Ocean & Environment. The Master's program will provide a solid foundation for the future development of a PhD degree program in Bioinformatics & Computational Systems Biology. The program will be synergistic to the existing degree programs, providing a critical component to University's strategic priorities in energy, environment, and life and health sciences, and serving as a pillar of UD's *Path to Prominence*.

II. RATIONALE AND DEMAND

The University of Delaware currently does not offer a specialized graduate degree in Bioinformatics & Computational Biology, although related courses have been taught in several departments for a number of years. We propose to develop a Master's program in Bioinformatics & Computational Biology. The rationales are:

- Bioinformatics & Computational Biology is essential to 21st century life science research in academia and industry;
- The program will build upon the research strength and bioinformatics infrastructure at the Delaware Biotechnology Institute and from departments across the Colleges of Arts & Sciences, Engineering, Agriculture & Natural Resources, and Earth, Ocean & Environment;
- The program will offer graduate education in a discipline essential for UD as a major research university, providing a critical component to University's strategic priorities in energy, environment, and life and health sciences. Indeed the program aligns with the University strategic plan to "*engage closely with the critical issues of our day, to increase the global impact of the University, and to raise its prominence in the world.*"

The rationale and specific objective of each degree in the Master's program in Bioinformatics & Computational Biology are:

1. *Master of Science in Bioinformatics & Computational Biology (BICB-MS), Computational Sciences Concentration (CS)*

The Master of Science in Bioinformatics & Computational Biology (BICB-MS) will provide an interdisciplinary program to foster research collaborations across Colleges, and will support the future development of a PhD degree program in Bioinformatics & Computational Systems Biology. The thesis-based BICB-MS degree will prepare students for advanced research. The Computational Sciences Concentration (CS) will allow students with strong quantitative sciences background to gain solid knowledge and research experience in developing computational methods and bioinformatics tools and databases for the study of biological systems. The

graduates may pursue further study towards a PhD or other professional degree, or a research career in academia, industry, or government agencies.

2. *Master of Science in Bioinformatics & Computational Biology(BICB-MS),*
   Life Sciences Concentration (LSC)

The Master of Science in Bioinformatics & Computational Biology (BICB-MS) will provide an interdisciplinary program to foster research collaborations across Colleges, and will support the future development of a PhD degree program in Bioinformatics & Computational Systems Biology. The thesis-based BICB-MS degree will prepare students for advanced research. The Life Sciences Concentration (LSC) will allow students with strong biological background to gain solid knowledge and research experience in applying bioinformatics methods, tools and databases as an integral approach to life science research. The graduates may pursue further study towards a PhD or other professional degree, or a research career in academia, industry, or government agencies.

3. *Professional Science Master's in Bioinformatics (BINF-PSM)*
   Computational Sciences Concentration (CS1)

The Professional Science Master's in Bioinformatics (BINF-PSM) will position UD as a regional leader in bioinformatics professional education. The scientific curriculum, together with "Plus" component for professional skills and the immersive Internship will well prepare the BINF-PSM graduates to pursue a career in industry, business, government agencies, or non-profit organizations. The Computational Sciences Concentration (CS1) will allow students with strong quantitative sciences background to gain solid knowledge and industry experience in developing bioinformatics methods, tools and/or databases for modern biotechnology or medicine.

4. *Professional Science Master's in Bioinformatics (BINF-PSM)*
   Life Sciences Concentration (LSC1)

The Professional Science Master's in Bioinformatics (BINF-PSM) will position UD as a regional leader in bioinformatics professional education. The scientific curriculum, along with "Plus" component for professional skills and the immersive Internship will well prepare the BINF-PSM graduates to pursue a career in industry, business, government agencies, or non-profit organizations. The Life Sciences Concentration (LSC1) will allow students with strong biological sciences background to gain solid knowledge and industry experience in applying bioinformatics methods, tools and databases as an integral approach to modern biotechnology and medicine.

5. *Graduate Certificate in Bioinformatics (BINF-CERT)*
   Computational Sciences Concentration (CS2)

The Graduate Certificate in Bioinformatics (BINF-CERT) will provide bioinformatics core competency. It is ideally suited for working professionals who cannot make a commitment to the BICB-MS or BINF-PSM program at this time, but can use the Certificate as a stepping stone. Current graduate students at UD can use the Certificate to gain bioinformatics skills. The Computational Sciences Concentration (CS2) will allow students with strong quantitative

sciences background to gain knowledge in developing bioinformatics methods, tools and/or databases for modern biotechnology or medicine.

6. *Graduate Certificate in Bioinformatics (BINF-CERT)*
   Life Sciences Concentration (LSC2)

The Graduate Certificate in Bioinformatics (BINF-CERT) will provide bioinformatics core competency. It is ideally suited for working professionals who cannot make a commitment to the BICB-MS or BINF-PSM program at this time, but can use the Certificate as a stepping stone. Current Master's or PhD students at UD can use the Certificate to gain bioinformatics skills. The Life Sciences Concentration (LSC2) will allow students with strong biological background to gain knowledge in applying bioinformatics methods, tools and databases as an integral approach to modern biotechnology or medicine.

A. INSTITUTIONAL FACTORS

A.1. COMPATIBILITY WITH UNIVERSITY ACADEMIC PRIORITIES

A strong educational program in Bioinformatics & Computational Biology will contribute to the scholarly and educational missions of the University—to *disseminate scientific, humanistic, and social knowledge for the benefit of the larger society* and to produce graduates who *are prepared to contribute to a global society*, addressing *the critical needs of the state, nation and global community*.

A.2. PLANNING PROCESS

The planning process started in Spring 2009 after the recruitment of Dr. Cathy H. Wu, Edward G. Jefferson Professor of Bioinformatics & Computational Biology, who was charged to take the responsibility and leadership for establishing the *Center for Bioinformatics & Computational Biology* at the University of Delaware and the development of new graduate programs in Bioinformatics & Computational Biology.

A Bioinformatics Steering Committee was established in June 2009 to guide the development of the Master's program in Bioinformatics & Computational Biology. The committee consists of faculty members from ten Departments across four Colleges participating in this degree program, with expertise in areas ranging from genomics and systems biology to biostatistics and high performance computing (Table 1). The committee meets monthly throughout the entire planning process to discuss all aspects of the program development.

Table 1. Bioinformatics Steering Committee

Member	College	Department	Expertise
Wu, Cathy (Chair)	Arts & Sciences	Computer & Information Sciences	Bioinformatics and Computational Biology
Antoniewicz, Maciek	Engineering	Chemical Engineering	Metabolic Engineering, Systems Biology

Bahnson, Brian	Arts & Sciences	Chemistry & Biochemistry	Structure Biology, Molecular Modeling
Duncan, Melinda	Arts & Sciences	Biological Sciences	Biotechnology PSM, Developmental Biology
Hanson, Thomas	Earth, Ocean & Environment	Marine Biosciences	Microbial Genomics
Lee, Kelvin	Engineering	Chemical Engineering	Systems Biology, Proteomics
Liao, Li	Arts & Sciences	Computer & Information Sciences	Bioinformatics and Computational Biology
Marsh, Adam	Earth, Ocean & Environment	Marine Biosciences	Environmental Bioinformatics
Meyers, Blake	Agriculture & Natural Resources	Plant & Soil Sciences	Plant Genomics, Bioinformatics
Rejto, Lidia	Agriculture & Natural Resources	Food & Resource Economics	Biostatistics
Schleiniger, Gilberto	Arts & Sciences	Mathematical Sciences	Quantitative Biology BS Major, Mathematical Biology
Schmidt, Carl	Agriculture & Natural Resources	Animal & Food Sciences	Avian Genomics
Taufer, Michaela	Arts & Sciences	Computer & Information Sciences	Grid Computing, Cloud Computing
Wommack, Eric	Agriculture & Natural Resources	Plant & Soil Sciences	Viral Genomics
Zurakowski, Ryan	Engineering	Electrical & Computer Engineering	Biomedical Engineering

Meanwhile, Dr. John Sawyer, Director of Professional Education Initiatives, Office of the Vice Provost for Graduate and Professional Education, has coordinated the development of the PSM programs on campus, and in particular, spearheaded the development of the "Plus" component. The initial effort has focused on the Biotechnology PSM (to be directed by Dr. Melinda Duncan, Graduate Program Director, Department of Biological Sciences) and the Bioinformatics PSM (to be directed by Dr. Cathy Wu). A key aspect of the PSM program development is to interact with the regional Biosciences industry to collaboratively define attributes of the course curriculum that are highly compatible to industry needs, and to detail the education benefits available to the employees in the participating organizations.

A Bioinformatics Industry Advisory Board was established in July 2009 to advise the development of the Master's program in Bioinformatics & Computational Biology from industry perspectives. The Board consists of representatives from major regional companies and institutions who have committed to host internships (Table 2).

Table 2. Bioinformatics Industry Advisory Board

Member	Title	Organization
Tomb, Jean-Francois (Chair)	Manager – Bioinformatics at DuPont	DuPont Central Research & Development

Barbara, Deb	VP, New Business Development	Strategic Diagnostics, Inc.
Bunnell, Tim	Director, Center for Pediatric Auditory & Speech Sciences	duPont Hospital for Children
Christianson, Anastasia	Director of Discovery Medicine Informatics	AstraZeneca
Foutrakis, George	Associate, GORE Medical Products	W.L. Gore
Hollis, Greg	VP, Applied Technology Group	Incyte
Weintraub, William	Director, Christiana Center for Outcomes Research	Christiana Care
Wright, Ian	Head of Global Assay Development	Siemens Healthcare Diagnostics

The Bioinformatics Graduate Committee was established in August 2009 to be responsible for the admission, advising, and progress assessment of the students in the Master's program in Bioinformatics & Computational Biology. The committee consists of at least two representative faculty members from each participating College in this degree program (Table 3).

Table 3. Bioinformatics Graduate Committee

Member	College	Department
Wu, Cathy (Chair)	Arts & Sciences	Computer & Information Sciences/ Biological Science
Hanson, Thomas	Earth, Ocean & Environment	Marine Biosciences
Lee, Kelvin	Engineering	Chemical Engineering
Liao, Li	Arts & Sciences	Computer & Information Sciences
Papoutsakis, Eleftherios	Engineering	Chemical Engineering
Patel, Sandeep	Arts & Sciences	Chemistry & Biochemistry
Rejto, Lidia	Agriculture & Natural Resources	Food & Resource Economics
Schleiniger, Gilberto	Arts & Sciences	Mathematical Sciences
Schmidt, Carl	Agriculture & Natural Resources	Animal & Food Sciences
Wommack, Eric	Agriculture & Natural Resources/ Earth, Ocean & Environment	Plant and Soil Sciences/ Marine Biosciences

A.3. SIGNIFICANT IMPACT ON OTHER UNIVERSITY PROGRAMS

The positive impact of the proposed Master's program in Bioinformatics & Computational Biology on University research and educational programs is multi-fold:

- It will offer graduate education in a discipline essential for University of Delaware as a major research university. According to the listing at the International Society for Computational Biology web site (http://www.iscb.org/iscb-degree-certificate-programs), there are presently 180 bioinformatics-related degree programs worldwide, almost 100 in the United States alone;
- It will provide courses that can be used as electives in current graduate and undergraduate degree programs, and used for the development of new minors, concentrations, or degree programs, thus, complementing, not competing with already existing degree programs;
- It will create a context for faculty from the various participating disciplines across-campus to articulate the interface of their research and foster research collaborations;

- It will produce graduate students with knowledge and professional expertise in bioinformatics and computational biology, who can play a key role in multi- and interdisciplinary teams;
- The educational program, coupling with collaborative interdisciplinary research, will provide a solid foundation for University of Delaware to compete for training grants (such as NSF's IGERT-Integrative Graduate Education and Research Traineeship Program and NIH's Institutional Research Training Grants) and research grants (such as NIH's CTSA-Clinical and Translational Science Award);
- The educational program will provide a solid foundation for the future development of a PhD degree program in Bioinformatics & Computational Systems Biology (planned for Fall 2012 start);
- As a supplementary benefit, offering the Professional Science Master's and the Graduate Certificate potentially represents a source of income for the University.

A.4. UTILIZATION OF EXISTING RESOURCES

With strong computational and engineering programs and full biological disciplines from health sciences to agriculture and marine studies, as well as state-of-the-art facilities for bioinformatics at the Delaware Biotechnology Institute, the University of Delaware provides a rich environment for educational programs in Bioinformatics & Computational Biology. The proposed curricula fully leverage the course offerings from the following departments/units across Colleges. The letters of approval from contributing department/units are attached in Appendix I.

College of Arts & Sciences:
 Department of Computer & Information Sciences
 Department of Biological Sciences
 Department of Chemistry & Biochemistry
 Department of Mathematical Sciences
College of Agriculture & Natural Resources
 Department of Plant & Soil Sciences
 Department of Food & Resource Economics
 Department of Animal & Food Sciences
College of Engineering
 Department of Electrical & Computer Engineering
 Department of Chemical Engineering
College of Earth, Ocean & Environment
 Marine Biosciences Program
College of Health Sciences
 Department of Health, Nutrition & Exercise Sciences
 Department of Physical Therapy
Alfred Lerner College of Business & Economics
 Department of Business Administration
 Department of Accounting & MIS
College of Education & Public Policy
 School of Urban Affairs & Public Policy
Office of the Vice Provost for Graduate & Professional Education
 Professional Education Initiatives

B. STUDENT DEMAND

According to many accredited scientific and industry reviews, bioinformatics and computational biology may well be the single fastest-growing specialty in the life sciences. A recent report estimates the current global bioinformatics market at about $1.4 billion, and is projecting an average annual growth rate of 15.8 per cent to reach nearly $3 billion by 2010, reflecting bioinformatics' explosive growth.

Meanwhile, the Professional Science Master's Program has evolved over the last decade across the USA. A report from the National Academies said, "*The time is right to accelerate and spread nationally the development of professional science master's degrees that are interdisciplinary in character, strongly emphasize effective communication and problem solving, and provide an understanding of entrepreneurial skills and technical innovation.*" The National Research Council recognizes PSM degree programs as uniquely promising for preparing bioscience talent.

B.1. ENROLLMENT PROJECTIONS

We project that we will have a steady increase in new students entering the Master's program in Bioinformatics & Computational Biology each year and reach 20 new students in the steady state, 10 for BICB-MS and 5 each for BINF-PSM and BINF-CERT, respectively. The projection is based on a M.S. Bioinformatics Track program established by Wu at Georgetown University, where enrollment has increased steadily each semester since its launching in Fall 2009. Based on the enrollment of similar programs, we project that 80% of BICB-MS student will be full-time, while 50% of BINF-PSM and BINF-CERT student will be full-time.

Full-time student is expected to complete the BICB-MS program (33 credits) or BINF-PSM program (42 credits) in two years. The program may be completed over a longer time frame for part-time students. The BINF-CERT program (15 credits) can be completed in one year, or longer on a part-time basis.

B.2. NEEDS OF STUDENT CLIENTELES

Launching the Master's program in Bioinformatics & Computational Biology with six degree options will support students from different educational backgrounds and with different career aspirations, while leveraging the common course curriculum. The students, full-time or part-time, may come from various biological, life sciences background, from computational, quantitative sciences and engineering background, or even from "unconventional" fields such as business, management, law and medicine. They may be interested in applying bioinformatics as an integral approach to life science research and development, or interested in developing new computational methods and bioinformatics tools and databases. Graduates of this program will leave well prepared to pursue careers for research, education, or development in academia, business, industry, government agencies, or non-profit organizations.

C. TRANSFERABILITY

Prior to admission to the Master's program in Bioinformatics & Computational Biology, a prospective student from another institution can be approved by the Graduate Committee to take up to 9 graduate credits that, if/when admitted to the degree program, would be applied to that degree. Graduate courses counted toward a degree received elsewhere may not be transferred into a degree at the University of Delaware. Once the student has successfully completed 9 approved graduate UD credits and been admitted to the degree program, then a maximum of 9 graduate credits can be transferred into the Master's program from another institution with the approval of the Graduate Committee.

Students who complete graduate credits with the classification of CEND (Continuing Education Non-degree) at the University of Delaware may use a maximum of 9 graduate credits earned with this classification toward their graduate degree. Students matriculated in other graduate degree programs upon admission to the Master's program in Bioinformatics & Computational Biology may transfer their graduate credits provided that: (i) the course was at the 600-800 level, (ii) the course was taken within the time limit appropriate for the degree, and (iii) the course was approved by the Graduate Committee and in accordance with the student's plan of study.

D. ACCESS TO GRADUATE AND PROFESSIONAL PROGRAMS

The graduates of the Master's program in Bioinformatics & Computational Biology will have different career paths. Some will decide to pursue a PhD in the participating departments. Other students, especially those enrolled in the BINF-PSM program and/or those have already been employed in industry or government may consider the program as a terminal degree.

E. DEMAND AND EMPLOYMENT FACTORS

The demand and growth of bioinformatics and computational biology as a research field and in the global industry have been discussed above (sections I and II.B). Our close collaboration with the regional Biosciences industry will provide opportunities for industry internship, career advising, as well as employment opportunities.

F. REGIONAL, STATE AND NATIONAL FACTORS

According to the listing at the International Society for Computational Biology web site, there are presently 180 bioinformatics-related degree programs worldwide, almost 100 in the United States alone.

F.1. COMPARABLE COURSES OF STUDY IN THE REGION OR STATE

No other university in the State of Delaware offers a Master's program in Bioinformatics & Computational Biology. In the Delaware Valley region, there are only two graduate degree programs in Bioinformatics & Computational Biology, an interdisciplinary Ph.D. program in Genomics and Computational Biology at the University of Pennsylvania, and a Master's (non-thesis M.S.) in Bioinformatics at the University of the Sciences in Philadelphia.

We believe that the UD Master's program in Bioinformatics & Computational Biology will emerge as a highly competitive educational opportunity based on: (i) a strong scientific core curriculum and comprehensive list of elective courses with many subfields in Life Sciences and Computational Sciences, (ii) proximity to major biotech and pharmaceutical industry and active participation of regional industry partners, (iii) rich opportunities for thesis research projects and immersive internships, and (iv) the competitive total cost of the degree program.

F.2. EXTERNAL REQUIREMENTS

We note that there are no formal guidelines for a Master's program in Bioinformatics & Computational Biology, nor are there accreditation standards. The proposed curriculum was designed based on a careful study of bioinformatics and computational biology curricula offered by other institutions. We have closely examined offered programs at selected, prominent research universities, conducted a series of talks with the local industry partners, and recognized the needs from both the student and employer perspectives. The proposed curriculum compiles the information gathered from these resources into one carefully tailored program.

G. OTHER STRENGTHS

G.1. SPECIAL FEATURES

A special feature of the proposed program is the close collaboration among participating Departments across Colleges. These departments are working together to develop and offer courses for this new Master's program in Bioinformatics & Computational Biology. Going forward, this collaboration will continue in the form of the Bioinformatics Steering Committee and the Bioinformatics Graduate Committee.

Another feature of the program is its coordination through the Center for Bioinformatics & Computational Biology, which provides extensive bioinformatics resources and capabilities at the BioIT Center at the Delaware Biotechnology Institute (DBI) and the Protein Information Resource (PIR). The BioIT Center provides both computing infrastructure and cyber-knowledgeable personnel with significant hardware, software and professional support for computational and data management needs. The computing infrastructure includes a High-Performance Compute Cluster, a Database Server Cluster, and an immersive 3-D Visualization Studio. The PIR is a public bioinformatics resource that provides integrated databases and analytical tools to support genomics, proteomics and systems biology research. The PIR web sites are freely accessible by researchers worldwide with over 4 million hits per month from over 100,000 unique sites, while the FTP sites serve over 1 terabyte of data download monthly.

G.2. COLLABORATIVE ARRANGEMENTS

No collaborative arrangement is required.

III. ENROLLMENT, ADMISSIONS AND FINANCIAL AID

A. ENROLLMENT

There is no need to limit enrollment due to resources. Enrollment is estimated at 20 new students per academic year in the steady state. Based on the entrance requirements and specified prerequisites, students may enroll in the Master's program with a regular status or provisional status:

- **Regular status** is offered to students who meet all of the established entrance requirements, who have a record of high scholarship in their fields of specialization, and who have the ability, interest, and maturity necessary for successful study at the graduate level in a degree program.
- **Provisional status** is offered to students who are seeking admission to the degree program but lack one or more of the specified prerequisites. All provisional requirements must be met within the deadline given before regular status can be granted. Students admitted with provisional status are generally not eligible for assistantships or fellowships. Students who file an application during the final year of undergraduate or current graduate work and are unable to supply complete official transcripts showing the conferral of the degree will be admitted pending conferral of the degree if their records are otherwise satisfactory and complete. For students lacking appropriate preparatory course work, additional courses applicable to certain areas of study may be required prior to admission or students may be admitted with the provision that completion of certain area content courses be completed concurrent with the courses in the degree program.

B. ADMISSION REQUIREMENTS

B.1. SELECTION CRITERIA

Admission to the graduate program is competitive. Those who meet stated requirements are not guaranteed admission, nor are those who fail to meet all of those requirements necessarily precluded from admission if they offer other appropriate strengths.

The following are the admission requirements to the Master's program in Bioinformatics & Computational Biology that apply to all three degrees (BICB-MS, BINF-PSM and BINF-CERT):

- A bachelor's degree at an accredited four-year college or university with a minimum grade average of 3.0 on a 4.0 system;
- Applicants may have undergraduate degrees from biological, computational, or other disciplines. However, applicants are expected to have scholarly competence in mathematics, computer science and/or biology;
- The following GRE scores are competitive: Quantitative: 650, Verbal + Quantitative: 1200. No GRE subject test is required;
- International student applicants must demonstrate a satisfactory level of proficiency in the English language if English is not the first language. The University requires an official TOEFL score of at least 550 on paper-based, 213 on computer-based, or 79 on

Internet-based tests. TOEFL scores more than two years old cannot be considered official. Alternatively, IELTS can be accepted in place of the TOEFL. The minimum IELTS score is 6.5 overall with no individual sub-score below 6.0.

- Three letters of recommendation are required. At lease one letter must be from professors, other letters can be from employers or others who have had a supervisory relationship with the applicant and are able to assess the applicant's potential for success in graduate studies; and
- Applications must also include a resume outlining work and academic experience, as well as an application essay consisting of the answers to the following questions:
  1. What educational background and scientific research or employment experience prepare you for this bioinformatics degree program?
  2. What are your long-term professional objectives?
  3. What specific attributes of the bioinformatics program make you feel that this degree is appropriate to help you achieve your professional objectives?

B.2. CHANGE OF CLASSIFICATION

Students currently matriculated in other graduate degree programs should complete a "Change of Classification Form" to seek approval to enter the Master's program in Bioinformatics & Computational Biology. The Bioinformatics Graduate Committee will evaluate each "Change of Classification" request on a case-by-case basis and determine whether the student is required to submit a completed admission application form to the Office of Graduate and Professional Education and follow the same procedures for admission as other applicants.

Students should also complete a "Change of Classification Form" for moving within the program, e.g., from BINF-CERT to BICB-MS or BINF-PSM; or from BICB-MS to BINF-PSM. The Bioinformatics Graduate Committee will evaluate and approve the transfer requests on a case-by-case basis. A student in the BICB-MS program who has been funded on a Graduate Assistantship will require the consent of the Faculty Advisor for transfer to another degree option in the program.

B.3. APPLICATION DEADLINES

Admission decisions are made on a rolling basis as and when applications are complete. The following application deadlines apply to all three degrees (BICB-MS, BINF-PSM and BINF-CERT):

- Fall Semester: July 1st (regular application); February 1st (financial aid)
- Spring Semester: December 1st (regular application); October 1st (financial aid)

C. STUDENT EXPENSES AND FINANCIAL AID

C.1. STUDENT EXPENSES

The Master's program in Bioinformatics & Computational Biology does not require student expenses beyond the traditional book and supplies, except for the availability of a personal computer or laptop.

C.2. FINANCIAL AID

Admission to the Master's program in Bioinformatics & Computational Biology does not automatically entitle an applicant to financial aid. Students may seek financial aid opportunities, such as fellowships or scholarships from sources within the University and from private and federal agencies. Interested students should check the Office of Graduate Studies for the most current opportunities.

Financial aid is awarded on a competitive basis from the pool of admitted applicants. The University of Delaware's policies apply to all forms of financial aid. Please refer to the University Policies for Graduate Student Assistantships and Fellowships.

Students in the BICB-MS program may apply for the Graduate Assistantships:

- **Research Assistantships (RAs)** are generally funded by research grants and contracts provided by external funding agencies. Students may be supported as an RA through their Faculty Advisor's research funds after their first year. A research assistantship provides full tuition and a stipend. The RA's advisor is responsible for defining the student's responsibilities and for evaluating the student's performance. The amount of service or research may vary from week to week but the average is usually expected to be 20 hours per week.
- **Teaching Assistantships (TAs)** are offered for graduate students to perform teaching and other instructional activities. The amount of service may vary from week to week but the average is usually expected to be 20 hours per week. A teaching assistantship provides full tuition and a stipend. In accordance with University of Delaware regulations, foreign students must achieve a TOEFL score of at least 600 (paper-based), 250 (computer-based) or 100 (Internet-based), or an IELTS score of at least 7.5 in order to qualify for teaching assistantships.

Students in the BINF-PSM program may apply for **Industry Internships**. Paid internships may be available from industry, government agencies or other participating institutions in the Master's program in Bioinformatics & Computational Biology.

IV. CURRICULUM SPECIFICS

A. INSTITUTIONAL FACTORS

Students who successfully complete the Master's program in Bioinformatics & Computational Biology may be awarded to one of the following degrees: Master of Science in Bioinformatics & Computational Biology (BICB-MS), Professional Science Master's in Bioinformatics (BINF-PSM), or Graduate Certificate in Bioinformatics (BINF-CERT). The degree will be awarded by the College of Arts and Sciences.

B. CURRICULUM DESCRIPTION

B.1. DEGREE REQUIREMENTS

The tables below list the degree requirements for each of the three degrees—Master of Science in Bioinformatics & Computational Biology (BICB-MS), Professional Science Master's in Bioinformatics (PSM-BINF), and Graduate Certificate in Bioinformatics (BINF-CERT), with the respective concentrations—Computational Sciences Concentration and Life Sciences Concentration.

1. **MASTER OF SCIENCE IN BIOINFORMATICS AND COMPUTATIONAL BIOLOGY: COMPUTATIONAL SCIENCES CONCENTRATION**

BICB-MS Computational Sciences Concentration (CS) – Degree Requirement	
33 Credit Hours Total	
Bioinformatics & Computational Biology Core – Computational Sciences	15 Credits
Ethics Core	3 Credits
Electives – Computational Sciences	6 Credits
Thesis	6 Credits
Seminar	3 Credits (1 Credit/Semester, P/F)

2. **MASTER OF SCIENCE IN BIOINFORMATICS AND COMPUTATIONAL BIOLOGY: LIFE SCIENCES CONCENTRATION**

BICB-MS Life Sciences Concentration (LSC) – Degree Requirement	
33 Credit Hours Total	
Bioinformatics & Computational Biology Core – Life Sciences	15 Credits
Ethics Core	3 Credits
Electives – Life Sciences	6 Credits
Thesis	6 Credits
Seminar	3 Credits (1 Credit/Semester, P/F)

3. **PROFESSIONAL SCIENCE MASTER'S IN BIOINFORMATICS: COMPUTATIONAL SCIENCES CONCENTRATION**

BINF-PSM Computational Sciences Concentration (CS1) – Degree Requirement	
42 Credit Hours Total	
Bioinformatics & Computational Biology Core – Computational Sciences	15 Credits
Ethics Core	3 Credits
Electives – Computational Sciences	6 Credits
Internship	6 Credits
Professional Science Master's Plus Courses (Business/ industry Track or Government/Non-Profit Track)	12 Credits

4. **PROFESSIONAL SCIENCE MASTER'S IN BIOINFORMATICS: LIFE SCIENCES CONCENTRATION**

BINF-PSM Life Sciences Concentration (LSC1) – Degree Requirement	
42 Credit Hours Total	
Bioinformatics & Computational Biology Core – Life Sciences	15 Credits
Ethics Core	3 Credits
Electives – Life Sciences	6 Credits
Internship	6 Credits
Professional Science Master's Plus Courses (Business/ industry Track or Government/Non-Profit Track)	12 Credits

5. **GRADUATE CERTIFICATE IN BIOINFORMATICS: COMPUTATIONAL SCIENCES CONCENTRATION**

BINF-CERT: Computational Sciences Concentration (CS2) – Degree Requirement	
15 Credit Hours Total	
Bioinformatics & Computational Biology Core – Computational Sciences	15 Credits

6. **GRADUATE CERTIFICATE IN BIOINFORMATICS: LIFE SCIENCES CONCENTRATION**

BINF-CERT: Life Sciences Concentration (LSC2) – Degree Requirement	
15 Credit Hours Total	
Bioinformatics & Computational Biology Core – Life Sciences	15 Credits

B.2. CURRICULUM

The tables below list the course curriculum for the major components of the Master's program in Bioinformatics & Computational Biology. New or revised courses required for the curriculum are marked. All of these courses have been submitted to the Course Challenge list and will be effective for the Fall 2010 term.

1. **BIOINFORMATICS & COMPUTATIONAL BIOLOGY CORE – COMPUTATIONAL SCIENCES**

Bioinformatics & Computational Biology Core – Computational Sciences (15)	
Bioinformatics (3)	CISC636: Bioinformatics (3) *
Introduction to Discipline (3) [select one]	ELEG671: Introduction to Biomedical Engineering (3)
	BISC602: Molecular Biology of Animal Cells (3)
	BISC612: Advanced Cell Biology (3)
	BISC654: Biochemical Genetics (3)
	PLSC636: Plant Genes and Genomes (3) *
	ANFS670: Principles of Molecular Genetics (3)

	MAST616: Methods in Molecular Biology (3)
Systems Biology (3)	MATH560: Introduction to Systems Biology (3) *
Database (3)	CISC637: Database Systems (3)
Biostatistics (3)	STAT613: Multivariate Statistical Methods with Biology Applications (3) *
[select one]	STAT656: Biostatistics (3)

CISC636: Bioinformatics (3) * submitted for re-title from "Introduction to Bioinformatics"
PLSC636: Plant Genes and Genomes (3) * submitted for re-title from "Advanced Plant Genetics"
MATH560: Introduction to Systems Biology (3) * adapted from MATH460
STAT613: Multivariate Statistical Methods with Biology Applications (3) * new course being developed

2. BIOINFORMATICS & COMPUTATIONAL BIOLOGY CORE – LIFE SCIENCES

Bioinformatics & Computational Biology Core – Life Sciences (15)	
Bioinformatics (3)	ANFS644: Bioinformatics
Introduction to Discipline (3)	MAST697: Bioinformatics Programming for Biologists *
Systems Biology (3)	MAST698: Environmental and Systems Bioinformatics *
Database (3)	CISC637: Database Systems (3)
Biostatistics (3)	STAT613: Multivariate Statistical Methods with Biology Applications (3) *
[select one]	STAT656: Biostatistics (3)

MAST697: Bioinformatics Programming for Biologists (3) * submitted for permanent status
MAST698: Environmental and Systems Bioinformatics (3) * submitted for permanent status
STAT613: Multivariate Statistical Methods with Biology Applications (3) * new course being developed

3. ETHICS CORE

Ethics Core (3)	
	BISC631: Practice of Science (3)
Ethics (3)	UAPP648: Environmental Ethics (3)
[select one]	UAPP650: Values Ethics and Leadership (3)
	BUAD840: Ethical Issues in Global Business Environments (3)

4. BIOINFORMATICS & COMPUTATIONAL BIOLOGY INTERNSHIP/SEMINAR/THESIS

Internship (6)	
Internship (6)	BINF864: Internship (1-6) *
Seminar (3)	
Seminar [3 semesters]	BINF865: Seminar (1) *
Thesis (6)	
Thesis (6)	BINF869: Master's Thesis (1-6) *

BINF864: Internship * new course listing
BINF865: Seminar * new course listing
BINF869: Master's Thesis * new course listing

5. ELECTIVES – COMPUTATIONAL SCIENCES

Electives – Computational Sciences (6)

Electives (6) [select two]	CISC841: Algorithms in Bioinformatics (3)
	CISC621: Algorithm Design and Analysis (3)
	CISC640: Computer Graphics (3)
	CISC642: Introduction to Computer Vision (3)
	CISC650: Computer Networks (3)
	CISC675: Object Oriented Software Engineering (3)
	CISC681: Artificial Intelligence (3)
	CISC683: Introduction to Data mining (3)
	CISC882: Natural Language Processing (3)
	CISC886: Multi-Agent Systems (3)
	CISC887: Internet Information Gathering (3)
	CISC888: Machine Learning (3)
	MATH607: Survey of Scientific Computing (3)
	MATH611: Introduction to Numerical Analysis and Scientific Computing (3)
	STAT670: Introduction to Statistical Analysis I (3) *
	STAT671: Introduction to Statistical Analysis II (3) *
	STAT608: Statistical Research Methods (3)
	STAT615: Design and Analysis of Experiments (3)
	STAT619: Time Series Analysis (3)
	STAT621: Survival analysis (3)
	STAT674: Applied Data Base Management (3)
	ELEG633: Image Processing (3)
	ELEG652: Principles of Parallel Computer Architectures (3)
	ELEG655: High-Performance Computing with Commodity Hardware (3)
	ELEG679: Introduction to Medical Imaging Systems (3)
	ELEG680: Immunology for Engineers (3)
	CHEG620: Biochemical Engineering (3)
	CHEG621: Metabolic Engineering (3)

STAT670: Introduction to Statistical Analysis I (3) * new course being developed
STAT671: Introduction to Statistical Analysis II (3) * new course being developed

6. ELECTIVES – LIFE SCIENCES

Electives – Life Sciences (6)	
Electives (6) [select two]	BISC600: Biotechnology and Molecular Medicine (3)
	BISC602: Molecular Biology of Animal Cells (3)
	BISC605 Advanced mammalian physiology (4)
	BISC612: Advanced Cell Biology (3)
	BISC615 Vertebrate Developmental Biology (3)
	BICS625: Cancer Biology (3)
	BISC641: Microbial Ecology (3)
	BISC645: Bacterial Evolution (3)
	BISC654: Biochemical Genetics (3)
	BISC656: Evolutionary Genetics (3)
	BISC665: Advanced Molecular Biology & Genetics (3)
	BISC671: Cellular and Molecular Immunology (3)
	BISC675 Cardiovascular Physiology (3)

	BISC679: Virology (3)
	BISC682: Bacterial Pathogens: Molecular Mechanisms (3)
	BISC693: Human Genetics (3)
	STAT670: Introduction to Statistical Analysis I (3) *
	STAT671: Introduction to Statistical Analysis II (3) *
	CHEM624: Principles of Mass Spectrometry (3)
	CHEM641: Biochemistry (3)
	CHEM645: Protein Structure and Function (3)
	CHEM646: DNA-Protein Interactions (3)
	CHEM649: Molecular Biophysics (3)
	ANFS670: Principles of Molecular Genetics (3)
	MAST616: Methods in Molecular Biology (3)
	MAST618: Marine Microbial Ecology (3)
	MAST623: Physiology of Marine Organisms (3)
	MAST625: Microbial Physiology and Diversity (3)
	MAST634: Marine Molecular Sciences (3)
	PLSC636: Plant Genes and Genomes (3) *
	PLSC644: Physiology of Plant Stress (3)
	HESC602: Data Analysis and Interpretation in Health Sciences (3)
	HESC654: Medical Physiology (3)
	PHYT606: Research (3)
	PHYT623: Clinical Neuroscience (4)
	PHYT633: Applied Physiology II (3)

STAT670: Introduction to Statistical Analysis I (3) * new course being developed
STAT671: Introduction to Statistical Analysis II (3) * new course being developed

7. PROFESSIONAL SCIENCE MASTER'S PLUS COURSES

Professional Science Master's Plus Courses – Business/Industry Track † (12)	
Survey of Business (3)	BUAD500: Survey of Business (3) *
Leadership and Organization (3)	BUAD870: Leadership and Organizational Behavior (3)
Project Management, Operations or Entrepreneurship (3) [select one]	BUAD831: Operations Management and Management Science (3)
	BUAD835: Managing New Product Development Projects (3)
	BUAD871: Managing for Creativity and Innovation (3)
	ENTR860: High Technology Entrepreneurship (3)
	MISY840: Project Management and Costing (3)
Intellectual Property (3)	CHEG595: Intellectual Property for Engineers and Scientists (3)
Professional Science Master's Plus Courses – Government/Non-Profit Track † (12)	
Survey of Public Administration(3)	UAPP803: Seminar in Public Administration (3)
Leadership and Organization (3) [select one]	UAPP835: Organization and Management (3)
	UAPP604: Leadership in Organizations (3)
Managerial Decision Making or Financial Management (3)	UAPP819: Management Decision Making in Public & Nonprofit Sectors (3)
	UAPP833: Financial Management in Public & Nonprofit Sectors (3)
	UAPP827: Program and Project Analysis (3)

[select one]	UAPP829: Taxation and Fiscal Policies (3)
Legal and Regulatory Affairs (3)	UAPP646: Administrative Law and Policy (3)

BUAD500: Survey of Business (3) * new course being developed

† Students are recommended to follow one of the tracks, but may cross over tracks to fit interest.

V. RESOURCES AVAILABLE

A. LEARNING RESOURCES

There are no special Learning Resources required to support this degree program. No new library or technology resources will be required for this Master's program in Bioinformatics & Computational Biology, as it will extend from the previous courses in the participating departments and build upon the bioinformatics infrastructure at the Delaware Biotechnology Institute. The library's current holdings and subscriptions have covered major bioinformatics journals (many are open-access) and are sufficient as instructional materials.

B. FACULTY/ADMINISTRATIVE RESOURCES

Faculty resources will be available to the Master's program in Bioinformatics & Computational Biology for course offerings from the participating departments (see letters of approval, pp. 86-103). Faculty members may serve as course directors, course instructors, and/or research mentors. The research mentors (thesis advisors or faculty co-mentors of industry internships) will also serve as the Faculty Advisor who will be the primary contact for students and will develop a course of study with the student before the beginning of the second semester.

All the courses in the curriculum will be offered every year, except for a few elective courses, which may be offered every other year. The total enrollment each year from the Master's program is projected at 20 students in the steady state. The demand from Bioinformatics & Computational Biology students can be absorbed by most existing classes. In a few cases, especially for the Core courses required for students in all degree options (such as CISC637 Database Systems), additional sections may be needed.

Additional faculty and administrative resources will be available from the Center for Bioinformatics & Computational Biology. These include: (i) four tenure-track faculty positions for faculty recruitment in critical areas of bioinformatics research and education–a search is currently underway for one position in the College of Arts & Sciences, (ii) an Administrative Assistant for administrative assistance for three years, and (iii) bioinformatics research faculty and scientific staff at the BioIT Center and PIR at Delaware Biotechnology Institute.

C. EXTERNAL FUNDING

Unidel Foundation funds have been requested to support a Scientific Coordinator position for three years at the Center for Bioinformatics & Computational Biology. The Coordinator will be

recruited at the rank of Research Assistant Professor to assist the Center Director in managing and coordinating activities in all three areas of research, education and core. If funded, the Coordinator will provide day-to-day management of the Master's program in Bioinformatics & Computational Biology and assist with student recruitment, admission, advising, progress assessment, and career planning. In addition, funds were requested to support Center activities including seminar series, training workshops and research symposiums. This will provide support for the Bioinformatics Seminar course (BINF865) and for an annual Research Day at the University of Delaware where MS and PSM students will present posters and showcase their thesis and internship projects.

VI. RESOURCES REQUIRED

A. LEARNING RESOURCES

Students in the program will utilize standard University computing systems. No new learning resources are required.

B. PERSONNEL RESOURCES

No additional personnel resources will be requested beyond the faculty and administrative resources described in Section V.

C. BUDGETARY NEEDS

C.1. PROJECTED EXPENSES

The projected expenses for the Master's program in Bioinformatics & Computational Biology include personnel costs for program administration, course instruction, mentoring and student scholarships, as well as costs for advertisement, materials and supplies and for hosting program activities. The expenses need to cover all six degree options—the Master of Science (MS), Professional Science Master's (PSM) and Graduate Certificate (CERT), each with two concentrations, the Computational Sciences Concentration and the Life Sciences Concentration.

	% Effort/Costs	Initial Funding
Personnel Expenses		
Program Administration		
Faculty Director	10%	Arts & Sciences (CBCB)
Program Coordinator (Research Faculty)	30%	Unidel (CBCB)
Administrative Assistant	20%	Arts & Sciences (CBCB)
Administration Personnel Total	0.6 FTE	
Course Instruction, Mentoring, Fellowships		
Additional Sections of Existing Courses	12.5%/course	Participating Departments/Colleges
New Course Development	12.5%/course	Participating Departments/Colleges

PSM Faculty Advisor	$5,000/student	Participating Departments/Colleges
Student Scholarships	50% tuition	Participating Departments/Colleges
Operational Expenses		
Web Design and Maintenance	$5,000	Arts & Sciences (CBCB)
Brochures and Advertisement	$20,000	Arts & Sciences (CBCB)
Materials and Supplies	$10,000	Arts & Sciences (CBCB)
Bioinformatics Seminars and Research Day	$10,000	Unidel (CBCB)
Operational Expenses Total	$45,000	

The initial funding for the administration personnel costs is available from the College of Arts & Sciences (and from the Unidel Foundation if funded) through the Center for Bioinformatics & Computational Biology (CBCB). The costs for course instruction by tenure-track faculty represent redirections of effort, as their salaries are already being paid by the respective Departments/Colleges. There may be needs to establish S-Contracts for part-time instructors to offer new sections of existing courses or to develop new courses in the future, especially for researchers or professionals from the collaborating companies and institutions who may provide industry perspectives and real-world problem-based learning.

The Bioinformatics Steering Committee further recommends that financial assistance be sought from Deans of the participating Colleges to provide: (i) tuition scholarships to outstanding students in the initial period of the Master's program to increase the prestige of the program, and (ii) tuition recovery for PSM Faculty Advisors who will serve as faculty co-mentor of industry internship and will be responsible for supervising the PSM students throughout their entire course of study.

Other operational expenses for the Master's program include recurring annual costs for recruitment and marketing, materials and supplies, and educational program activities. The latter will include honorarium and travel supports for invited speakers participating in the Bioinformatics Seminar course and the Research Day, as well as costs for hosting the Research Day events and student poster presentations.

C.2. BUDGET PLAN

The tuition income constitutes the major income for the Master's program in Bioinformatics & Computational Biology. Based on the assumption that we will have a steady increase in new enrollment of full-time student equivalents (FTEs) from seven students in year one to 20 students in year four when it reaches a steady state, the program is likely to have a net income starting the third year. The table below provides the projection of the number of new admits each year and the total number of students of the two-year program.

Student Enrollment (New/Total FTEs)	Y01	Y02	Y03	Y04	Y05
Master of Science (MS)	3/3	5/8	7/12	10/17	10/20
Professional Science Master (PSM)	2/2	3/5	5/8	5/10	5/10
Graduate Certificate (CERT)	2/2	3/5	5/8	5/10	5/10
Total Students	7/7	11/18	17/28	20/37	20/40

A budget plan should be in place and agreed upon among the Deans of the participating Colleges to cover the costs of launching the program initially, to incentivize faculty members to participate and contribute to this educational program, and to share the profit generated by the success of the program.

The proposed Master's program in Bioinformatics & Computational Biology is fully endorsed by the Deans of the following participating Colleges. Their letters of support are attached in Appendix II.

> College of Arts & Sciences:
> College of Agriculture & Natural Resources
> College of Engineering
> College of Earth, Ocean & Environment

VII. IMPLEMENTATION AND EVALUATION

A. IMPLEMENTATION PLAN

The Master's program in Bioinformatics & Computational Biology is planned for an official start in the Fall semester of 2010. The Bioinformatics Graduate Committee will establish policies of their operation and for the program, and coordinate with the home department and other participating departments about course offerings.

Simultaneously with this proposal, Faculty Senate approval will be sought for new or revised courses required for the curriculum, as submitted to the Course Challenge list.

B. ASSESSMENT PLAN

B.1. PROGRAM OBJECTIVE

The Master's program in Bioinformatics & Computational Biology aims to train the next-generation of researchers and professionals who will play a key role in multi- and interdisciplinary teams, bridging life sciences and computational sciences. The *Master of Science degree* will prepare students for advanced research in bioinformatics and computational biology; the *Professional Science Master's degree* will well prepare students for a bioinformatics professional career in industry, business, government agencies, or non-profit organizations; while the *Graduate Certificate* will provide bioinformatics core competency.

B.2. CURRICULAR MAP AND LEARNING OUTCOMES

The Master's program has five major curriculum components:
1. Science Core in Bioinformatics & Computational Biology
2. Ethics Core
3. Science Electives in Bioinformatics & Computational Biology
4. Seminar/Thesis/Internship in Bioinformatics & Computational Biology

5. Professional Science Master's Plus Courses

The curricular map indicates the following learning outcomes addressed in the curriculum:
1. Core competency in bioinformatics & computational biology
2. Knowledge of scientific/business ethics
3. Advanced knowledge of bioinformatics & computational biology and related disciplines
4. Independent mentored research experience in bioinformatics & computational biology
5. Working experience of bioinformatics in industry and business
6. Competence in scientific communication
7. Experience working with interdisciplinary teams, bridging life sciences and computational sciences
8. Professional knowledge and skills in business or public administration, leadership and organization, project management, and legal and regulatory affairs

Curriculum	Learning Outcomes							
	Core competency in Bioinformatics	Knowledge of ethics	Advanced knowledge of bioinformatics & related disciplines	Independent research experience	Working experience of bioinformatics in industry	Competence in scientific communication	Experience working with interdisciplinary teams	Professional knowledge and skills
Science Core	x							
Ethics Core		x						
Science Electives			x					
Seminar			x			x		
Thesis			x	x		x	x	
Internship			x		x	x	x	
PSM Plus								x

B.3. ASSESSMENT PLAN

Objectives	Strategic Activities	Measures	Short-term Outcomes	Long-term Impact

Train students in the science disciplines pertinent to bioinformatics & computational biology	Recruit excellent applicant and matriculate students with credentials similar to those in UD graduate programs	Number and demographic data of student applicants and matriculated students	Retention and time to degree statistics	Students gain employment in bioinformatics related fields
	Course work covering the disciplines related to bioinformatics & computational biology (Science Core and Electives)	Faculty evaluation of student progress in course work; Survey of faculty advisors and internship mentor; Surveys of graduate students in the program and post-graduation	Course work helped students secure initial employment; Students and graduates report applying knowledge from courses to work settings	Graduates enjoy long term success in academic or professional careers
Provide training in science-related ethics, business, organizational management, project management, legal and regulatory affairs	Course work addressing these issues and industry internship experience (Ethics Core and PSM Plus)	Surveys of students focusing on their experiences in these classes; Surveys of graduates to determine the utility of these classes to their career; Faculty evaluation of student progress in course work; Interviews and surveys of internship mentors	Course work for the PSM degree helped students secure industry internships and initial employment; Students and graduates report applying knowledge from courses to work settings	Graduates enjoy long term success in professional careers
Provide experiential training in academia or industry research or development to prepare students for the expectations of the workplace	Mentored research or development projects in academia, industrial or government settings (Internship, Thesis); Lectures and discussions on specialized topics	Surveys of students focusing on their experiences in their internship or thesis; Surveys of graduates to determine the utility of their experiential training to their career; Faculty advisor and internship mentor evaluation of both	Experiential training prepares students for the workplace and helps them secure their first post-graduation position	Graduates enjoy long term success in academic or professional careers

and cutting-edge developments (Seminar)	the project and the written reports and presentation; Interviews and surveys of faculty advisors and internship mentors		

Program improvement will be an ongoing process. The results of the assessment measures will be shared with the Bioinformatics Steering Committee, the Bioinformatics Industry Advisory Board and the Bioinformatics Graduate Committee. The curriculum will be modified as necessary to achieve the goal of producing graduates who apply the knowledge, skills and abilities gained from the Master's program in Bioinformatics & Computational Biology to their career.

VIII. APPENDIX I

LETTERS OF APPROVAL FROM CONTRIBUTING DEPARTMENTS/UNITS

College of Arts & Sciences

1. Dr. David Saunders, Chair, Department of Computer & Information Sciences [Academic Home Department]
2. Dr. Randall Duncan, Chair, Department of Biological Sciences
3. Dr. Peter Monk, Chair, Department of Mathematical Sciences
4. Dr. Klaus Theopold, Chair, Department of Chemistry & Biochemistry

College of Agriculture & Natural Resources

5. Dr. Jack Gelb Jr., Chair, Department of Animal & Food Sciences
6. Dr. Thomas Ilvento, Chair, Department of Food & Resource Economics
7. Dr. Blake Meyers, Interim Chair, Department of Plant & Soil Sciences

College of Engineering

8. Dr. Kenneth Barner, Chair, Department of Electrical & Computer Engineering
9. Dr. Norman Wagner, Chair, Department of Chemical Engineering

College of Earth, Ocean & Environment

10. Dr. Charles Epifanio, Director, School of Marine Science and Policy

College of Health Sciences

11. Dr. Susan Hall, Chair, Department of Health, Nutrition & Exercise Sciences
12. Dr. Stuart Binder-Macleod, Chair, Department of Physical Therapy

Alfred Lerner College of Business & Economics

13. Dr. Rick Andrews, Chair, Department of Business Administration
14. Dr. Guido Geerts, Chair, Department of Accounting & management Information Systems

College of Education & Public Policy

15. Dr. Maria Aristigueta, Director, School of Urban Affairs & Public Policy

Office of the Vice Provost for Graduate & Professional Education

16. Dr. John Sawyer, Associate Provost for Professional Education

UNIVERSITY OF DELAWARE

Department of Computer and Information Sciences
University of Delaware
103 Smith Hall
Newark, DE 19716
(302) 831-6238
saunders@cis.udel.edu

October 15, 2009

Cathy H. Wu, Ph.D.
Edward G. Jefferson Professor of Bioinformatics & Computational Biology
Department of Computer & Information Sciences
Delaware Biotechnology Institute
University of Delaware
15 Innovation Way, Suite 205
Newark, DE 19711

Dear Cathy,

The Department of Computer and Information Sciences is pleased to support core and elective courses for the proposed Professional Science Masters in Bioinformatics (BINF-PSM) and Masters of Science in Bioinformatics and Computational Biology (BICB-MS) degree programs and for the Graduate Certificate in Bioinformatics (BINF-CERT).

In particular, as we have discussed, we will work together to ensure that the courses CISC636 Bioinformatics and CISC637 Database Systems will be taught in such a way (1) to be accessible to students of varied degrees of preparation in computation and biology and (2) to continue to provide rigorous training in these subjects for CIS graduate students and BINF/BICB students alike.

The elective CISC6xx courses listed are normally taught every year, some of them every semester. Likewise the CISC8xx course electives usually are offered each year, though occasionally they appear 3 or 4 semesters apart. Courses do sometimes fill to capacity, but I anticipate that our schedule of offerings and the number of seats available will provide a rich set of options for students in this program without difficulty.

The Department of Computer and Information Sciences is pleased to contribute to the education of students in this important area. These programs will be a benefit to the University of Delaware and to our society.

Sincerely,

B. David Saunders

UNIVERSITY OF DELAWARE

DEPARTMENT OF BIOLOGY

OFFICE OF THE CHAIR

University of Delaware
Newark, Delaware 19716-2590
Ph: 302/831-6977
Fax: 302/831-2281

Randall L. Duncan, Ph.D.
Professor and Chairman
Department of Biological Sciences
118C Wolf Hall
Telephone (302) 831-6977
Fax No. (302) 831-1033
E-mail: rlduncan@udel.edu

October 12, 2009

Cathy H. Wu, Ph.D.
Edward. G. Jefferson Chair
Professor, Computer & Information Sciences and
Professor, Biological Sciences
Delaware Biotechnology Institute
15 Innovation Way, Suite 205
University of Delaware
Newark, DE 19711

Dear Cathy,

We shall be happy to make available seats in graduate courses in Biological Sciences, which will serve as electives in your proposed Masters of Science degree in Bioinformatics. As a proviso, I cannot guarantee the availability of space for all comers at all times since some of the listed courses often reach their enrollment limits. However, several courses on the list seldom reach enrollment limits and we are willing to consider increasing the available sections for the most popular graduate classes in the future if there is sufficient demand.

Please let me know if you require anything else in this regard. We wish you much success with this new initiative.

Best regards,

Professor and Chair

DEPARTMENT OF BIOLOGY

OFFICE OF THE CHAIR

University of Delaware
Newark, Delaware 19716-2590
Ph: 302/831-6977
Fax: 302/831-2281

Randall L. Duncan, Ph.D.
Professor and Chairman
Department of Biological Sciences
118C Wolf Hall
Telephone (302) 831-6977
Fax No. (302) 831-1033
E-mail: rlduncan@udel.edu

October 13, 2009

Cathy H. Wu, Ph.D.
Edward. G. Jefferson Chair
Professor, Computer & Information Sciences and
Professor, Biological Sciences
Delaware Biotechnology Institute
15 Innovation Way, Suite 205
University of Delaware
Newark, DE 19711

Dear Cathy,

We shall be happy to make available seats in graduate courses in Biological Sciences, which will serve as electives in your proposed Professional Science Masters degree in Bioinformatics. As a proviso, I cannot guarantee the availability of space for all comers at all times since some of the listed courses often reach their enrollment limits. However, several courses on the list seldom reach enrollment limits and we are willing to consider increasing the available sections for the most popular graduate classes in the future if there is sufficient demand.

 Please let me know if you require anything else in this regard. We wish you much success with this new initiative.

Best regards,

Professor and Chair

DEPARTMENT OF
MATHEMATICAL SCIENCES

501 Ewing Hall
University of Delaware
Newark, Delaware 19716-2553
Ph: 302/831-2653
Fax: 302/831-4511/4456

October 14, 2009

Prof Cathy Wu
Department of Computer and Information Sciences
University of Delaware
Newark, DE 19716

Dear Dr. Wu,

The Department of Mathematical Sciences is pleased to support core and elective courses for the Professional Science Master's (PSM) and certificate programs in bioinformatics.

The Department has proposed a new course, MATH 560 -- Introduction to Systems Biology, that may serve as a core course, and it offers courses in scientific computation that could serve as electives for the bioinformatics programs, namely MATH 607, MATH 611 and MATH 612. Although MATH 611/612 may be renumbered and revised to include some updating, the new courses would still serve the same purpose.

MATH 560, MATH 607, and MATH 611 are courses scheduled to be offered every fall semester and MATH 612 every spring.

The Department is enthusiastic about the possibility of collaborating with the new bioinformatics programs.

Sincerely,

Peter Monk
Chair and UNIDEL Professor

cc G. Schleiniger

UNIVERSITY OF DELAWARE

DEPARTMENT OF CHEMISTRY
AND BIOCHEMISTRY

OFFICE OF THE CHAIRMAN

102 Brown Laboratory
University of Delaware
Newark, Delaware 19716-2522
Ph: 302/831-1247
Fax: 302/831-6335

September 30, 2009

Cathy H. Wu, Ph.D.
Edward G. Jefferson Professor of Bioinformatics & Computational Biology
Department of Computer & Information Sciences
Delaware Biotechnology Institute
University of Delaware
15 Innovation Way, Suite 205
Newark, DE 19711

Dear Prof. Wu:

The Department of Chemistry & Biochemistry strongly supports enrollment of students
in our graduate level courses that are listed as electives for your proposed Professional
Science Masters in Bioinformatics (BINF-PSM) and Masters of Science in
Bioinformatics and Computational Biology (BICB-MS) degree programs.

The Department has submitted a proposal for the regularization of CHEM 684 titled
Biochemistry of Nucleic Acids, which will be offered each spring semester. You may
consider adding this course to your list of electives.

Each of the courses that are listed in your BINF-PSM or BICB-MS program under the
Life Sciences elective are offered once per year. The courses CHEM 641
(Biochemistry), CHEM 645 (Protein Structure and Function) and CHEM 646 (DNA-
Protein Interactions) are offered in the fall semester. The CHEM 641 course has two
sections open. The courses CHEM 624 (Principles of Mass Spectrometry) and CHEM
649 (Molecular Biophysics) are offered each spring. These courses typically have room
for additional enrollment, and we would welcome BINF-PSM and BICB-MS enrollment
to fill open seats in these classes.

The Department of Chemistry & Biochemistry is excited to be a part of this initiative and
looks forward to teaching students from these new programs.

With best regards,

Klaus H. Theopold
Professor and Chair

e-mail: theopold@udel.edu

UNIVERSITY OF DELAWARE.

**DEPARTMENT OF ANIMAL
AND FOOD SCIENCES**

Townsend Hall
University of Delaware
Newark, Delaware 19716-2150
Ph: 302//831-2524

October 14, 2009

MEMORANDUM

To: Cathy Wu
        Ed. G. Jefferson Endowed Professor
        Computer & Info Sciences

From: Jack Gelb, Jr., Chair
        Animal and Food Sciences

I am providing this letter of support at the request of Dr. Carl Schmidt of our department. I will also copy Dr. Limin Kung, Chair of the ANFS Courses and Curriculum Committee.

The Department of Animal and Food Sciences is pleased to support the core course offerings for the proposed Master's degree program in Bioinformatics and Computational Biology.

Specifically, we are prepared to offer ANFS 644 Bioinformatics-3 hr. At the present time, this course is offered during the fall semester each year.   Currently, one section is offered and students enrolled in the Master's degree program in Bioinformatics and Computational Biology may use seats in the existing section. Typical enrollment is approximately ten students, but there is space for twenty in the computer laboratory located in Townsend Hall. If necessary, the course could be offered in a larger computer laboratory on the main campus.

The Department of Animal and Food Sciences will benefit from such a Master's program here at the University of Delaware and we look forward to providing instruction for the enrolled students.

c. Carl Schmidt
   Limin Kung

Thomas W. Ilvento
213 Townsend Hall
University of Delaware
Newark, DE 19716-2130
Ph: 302-831-6773
Fax: 302-831-6243
Ilvento@udel.edu

October 13, 2008

Cathy H. Wu, Ph.D.
Edward G. Jefferson Professor of Bioinformatics & Computational Biology
Center for Bioinformatics and Computational Biology (CBCB)

Dear Dr. Wu,

The Department of Food and Resource Economics will support the following courses for inclusion in the Masters in Bioinformatics and the Profession Science Masters in Bioinformatics. By supporting these courses we acknowledge our intent to teach these courses on a regular basis and to admit nonmajors into these course as appropriate.

STAT 608   Statistical Research Methods I
STAT 615   Design and Analysis of Experiments
STAT 619   Time Series Analysis
STAT 621   Survival Analysis
STAT 656   Biostatistics
STAT 674   Applied Data Management

The following courses are under the process for revision or a new course. We expected these to be approved in this fiscal year

STAT 670   Introduction to Statistical Analysis I
STAT 671   Introduction to Statistical Analysis II
STAT 613   Multivariate Statistical Methods with Biological Applications

Please call or e-mail if you have any further questions or need anything else from me.

Sincerely,

Thomas W. Ilvento
Professor and Chair, Department of Food and Resource Economics

DEPARTMENT OF PLANT AND SOIL SCIENCES

OFFICE OF THE CHAIR

University of Delaware
Newark, DE 19717-1303
Ph:302/831-8153
Fax: 302/831-0605
Email: meyers@dbi.udel.edu

September 28, 2009

The Department of Plant & Soil Sciences is pleased to support breadth courses for Professional Science Master's (PSM) degree programs.

PLSC636: Advanced Plant Genetics is offered during the fall semester. This course is an advanced survey of genetics and genomics in higher plants, including molecular methods of plant biotechnology. Topics include genome composition and evolution, disease resistance, transposable elements and retrotransposons, DNA methylation and epigenetics, quantitative traits, chromosome structure and gene expression. One section of the course is offered each year, and PSM may utilize open seats in existing classes.

PLSC644: Physiology of Plant Stress will be offered during either the fall or spring semester. This course focuses on the response of plants to biotic and abiotic environmental stresses; mineral nutrients, salt, drought, cold, heat, light, pathogens and herbivores at the physiological and molecular levels. At least one section of the course is offered each year, and PSM may utilize open seats in existing classes.

PLSC667: Analytical Plant Genetics will be offered during either the fall or spring semester and is listed as a seminar course only because it is new. It will be taught as a regular course in the coming years.

The Department Plant and Soil Sciences is excited to be a part of this initiative and looks forward to seeing PSM and other students in the classroom.

Sincerely,

Blake Meyers
Professor

September 28, 2009

Dr. Cathy Wu
Ed. G. Jefferson Endowed Prof., Computer & Info Sciences
Professor, Biological Sciences
103 Smith Hall

Dear Professor Wu:

The Department of Electrical and Computer Engineering is pleased to support core and elective courses for the Bioinformatics and Computational Biology Master of Sciences (MS) and Bioinformatics Professional Science Master's (PSM) degree programs.

ELEG671 (Introduction to Biomedical Engineering) is a core course for the program, and is offered during Fall semesters. One section of the course is offered each year, and the program may utilize open seats in existing classes.

ELEG633 (Image Processing), ELEG652 (Principles of Parallel Computer Architectures), ELEG655 (High-Performance Computing with Commodity Hardware), ELEG679 (Introduction to Medical Imaging Systems) and ELEG680 (Immunology for Engineers) are elective options for both programs; demand for these courses can be spread to use seats in available sections. ELEG 652, ELEG655, and ELEG679 are offered regularly, while ELEG633 and ELEG680 are offered less frequently (every other year as demand permits).

The Department of Electrical and Computer Engineering is excited to be a part of this initiative and looks forward to seeing MS and PSM students in the classroom.

Regards,

Kenneth Barner
Professor and Chair

DEPARTMENT OF
CHEMICAL ENGINEERING

OFFICE OF THE CHAIRMAN

University of Delaware
Newark, Delaware 19716-3110
Ph: 302/831-8079 or 831-8155
Fax: 302/831-8201

October 14, 2009

To Whom It May Concern:

The Department of Chemical Engineering is pleased to support elective courses for the Professional Science Master's (PSM) degree programs in Bioinformatics and Computational Biology.

CHEG620 (Biochemical Engineering, 3 credits) is offered every year during the Spring semester. PSM students may utilize open seats in the class.

CHEG621 (Metabolic Engineering, 3 credits) is offered every year during the Spring semester. The course is available to PSM and other graduate/undergraduate students.

The Department of Chemical Engineering is excited to be a part of this initiative and looks forward to seeing PSM and other students in the classroom.

Sincerely,

Norman J. Wagner
Alvin B. and Julia O. Stiles Professor and Department Chairperson

COLLEGE OF EARTH, OCEAN, AND ENVIRONMENT

SCHOOL OF MARINE SCIENCE
AND POLICY

INTERIM DIRECTOR

University of Delaware
Hugh R. Sharp Campus
700 Pilottown Road
Lewes, DE 19958-1298 U.S.A
Ph: 302/645-4263
Fax: 302/645-4213
E-Mail: epi@udel.edu
URL: www.ceoe.udel.edu

October 12, 2009

Prof. Cathy Wu
Jefferson Chair in Bioinformatics
Director, Center for Bioinformatics and Computational Biology Department of Computer and Information Sciences

Dear Professor Wu:

The School of Marine Science and Policy is pleased to support core courses for the Professional Science Master's (PSM) and Master of Science degree programs and Graduate Certificate program in Bioinformatics and Computational Biology.

Prof. Adam Marsh, within the Marine Biosciences Program, has submitted two course proposals that will provide part of the core curriculum for the Life Sciences concentrations within each of these programs. These are MAST697: Bioinformatics Programming for Biologists and MAST698: Environmental and Systems Bioinformatics. MAST697 will serve as an entry point for biologists who have used bioinformatics tools that are seeking to acquire skills to customize these tools, collect them into pipelines and develop their own tools by developing basic proficiency in PERL, R, and Python languages that are commonly applied in bioinformatics. MAST698 will serve as an overview of bioinformatic analyses for "-omics" data: genomics, transcriptomics, and proteomics. The course will focus on the analysis of real world data sets so that students are exposed to realistic challenges in analyzing the staggering amounts of data produced by these techniques. Prof. Thomas Hanson will co-teach MAST698 with Prof. Marsh.

The School of Marine Science and Policy strongly supports this initiative. We expect that the courses above will be subscribed by not only Bioinformatics and Computational Biology students, but will also attract students from SMSP, particularly the Marine Biosciences Program, and other life science programs where students need to apply these techniques to their own research questions.

Sincerely,

Charles E. Epifanio, Director
School of Marine Science and Policy

COLLEGE OF HEALTH SCIENCES

DEPARTMENT OF HEALTH, NUTRITION, AND EXERCISE SCIENCES

Carpenter Sports Building
University of Delaware
Newark, Delaware 19716-3750
Ph: 302/831-2265
Fax: 302/831-4261

October 16, 2009

Cathy H. Wu, Ph.D.
Edward G. Jefferson Professor of Bioinformatics & Computational Biology
Department of Computer & Information Sciences
Delaware Biotechnology Institute
University of Delaware
15 Innovation Way, Suite 205
Newark, DE 19711

Dear Professor Wu,

The Department of Health, Nutrition, and Exercise Sciences is pleased to support your proposal for the Masters Program in Bioinformatics and Computational Biology. Specifically, we will allow students in the program enrollments in elective courses HESC602, Data Analysis and Interpretation in Health Sciences, and HESC654, Medical Physiology. We wish you success with the program.

Sincerely,

Susan J. Hall
Professor and Department Chair

301 McKinly Laboratory
University of Delaware
Newark, Delaware 19716-2591
Ph: 302/831-8046
Fax: 302/831-4234

October 13, 2009

Cathy H. Wu, Ph.D.
Edward G. Jefferson Professor of Bioinformatics & Computational Biology
Department of Computer & Information Sciences
Delaware Biotechnology Institute
University of Delaware
15 Innovation Way, Suite 205
Newark, DE 19711

Dear Prof. Wu:

Welcome to the University of Delaware. The Department of Physical Therapy is very pleased to support your efforts in the development a new Master's program for in Bioinformatics and would welcome students from the program to take appropriate elective courses within the Department. As we discussed, we believe appropriate courses would include: PHYT633 -Applied Physiology II, PHYT623 – Clinical Neuroscience, and PHYT606 – Research.

The Department of Physical Therapy is excited to be a part of this initiative and looks forward to teaching students from this new program.

Sincerely,

Stuart Binder-Macleod, PT, PhD, FAPTA
Edward L. Ratledge Professor and Chair
Department of Physical Therapy

UNIVERSITY OF DELAWARE

LERNER COLLEGE OF BUSINESS & ECONOMICS

DEPARTMENT OF BUSINESS ADMINISTRATION

Dr. Rick L. Andrews
Deputy Dean, Lerner College of Business & Economics
Chair, Department of Business Administration
Professor of Marketing
Lerner College of Business & Economics
University of Delaware
Newark, DE 19716

Phone: (302) 831-1190
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Email: andrewsr@udel.edu
website: http://www.buec.udel.edu/andrews/

September 8, 2009

The Department of Business Administration is pleased to support breadth courses for Professional Science Master's (PSM) degree programs.

The Department has submitted a proposal for a new breadth course, BUAD500 (SURVEY OF BUSINESS). Starting Spring 2011, one section of the course will be offered every year. The course will be available to PSM and other graduate students across campus who are not matriculated in graduate programs in the Lerner College of Business & Economics.

BUAD840 (ETHICAL ISSUES IN DOMESTIC AND GLOBAL BUSINESS ENVIRONMENTS) is offered during Fall and Spring semesters. Three or four sections of the course are offered each year, and PSM may utilize open seats in existing classes.

BUAD870 (LEADERSHIP AND ORGANIZATIONAL BEHAVIOR) is offered during Fall and Spring semesters. At least four sections of the course are offered each year, and PSM may utilize open seats in existing classes.

BUAD835 (MANAGING NEW PRODUCT DEVELOPMENT PROJECTS), BUAD831 (OPERATIONS MANAGEMENT AND MANAGEMENT SCIENCE) and BUAD871 (MANAGING FOR CREATIVITY AND INNOVATION) are options among a set of five courses; demand for these courses can be spread to use seats in available sections. BUAD831 and BUAD871 are offered regularly, while BUAD835 will be offered less frequently (not more than once per year and perhaps not every year).

The Department of Business Administration is excited to be a part of this initiative and looks forward to seeing PSM and other students in the classroom.

Regards,

Rick Andrews

Dr. Rick L. Andrews

UNIVERSITY OF DELAWARE

September 17, 2009

To: Dr. John E. Sawyer, Associate Provost for Professional Education
RE: PSM Degree Programs

Dear Dr. Sawyer,

The Department of Accounting and MIS is pleased to support the following two breadth courses for Professional Science Master's (PSM) degree programs:

- ENTR860 (HIGH TECH ENTERPRENEURSHIP) is offered during Spring semester. One section of the course is offered each year, and PSM may utilize open seats in existing classes.

- MISY840 (PROJECT MANAGEMENT AND COSTING) is offered during Spring semester. One section of the course is offered each year, and PSM may utilize open seats in existing classes.

The Department of Accounting and MIS is excited to be a part of this initiative and looks forward to seeing PSM and other students in the classroom.

Regards,

Dr. Guido L. Geerts
Chair, Department of Accounting and MIS
Lerner College of Business and Economics
Purnell Hall 226
Phone: 302-831-6413
E-mail: geertsg@lerner.udel.edu

COLLEGE OF HUMAN SERVICES, EDUCATION & PUBLIC POLICY

SCHOOL OF URBAN AFFAIRS
AND PUBLIC POLICY

Graham Hall
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Newark, Delaware 19716-7310
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E-mail: SUAPP@UDEL.EDU
Internet: www.udel.edu/suapp

September 30, 2009

John E. Sawyer, Ph.D.
Associate Provost for Professional Education Office of Graduate and Professional Education &
Professor & Director - Organizational Effectiveness, Development, and Change
Department of Business Administration
Alfred Lerner College of Business & Economics
320 Lerner Hall
University of Delaware
Newark, DE 19716

Dear Professor Sawyer:

The faculty of the School of Urban Affairs and Public Policy voted unanimously to enthusiastically support the Professional Science Master's Program (PSM Plus). I have reviewed the proposal and this program requires a selection from the following courses in the Government/Non-Profit track—UAPP 803, UAPP835, UAPP604, UAPP819, UAPP833, UAPP827, UAPP829, UAPP646, UAPP648 and UAPP650. We will make these courses available to the PSM Plus students on semesters in which they offered.

I look forward to working with you on this major and on other collaborations in the future.

Regards,

Maria P. Aristigueta
Professor and Director
School of Urban Affairs and Public Policy

OFFICE OF GRADUATE & PROFESSIONAL EDUCATION

ASSOCIATE PROVOST
PROFESSIONAL EDUCATION

University of Delaware
Newark, Delaware 19716-2710
Ph: 302-831-4377
Fax: 302-831-8745
E-mail: sawyerj@udel.edu

October 15, 2009

Cathy H. Wu, Ph.D.
Edward. G. Jefferson Chair
Professor, Computer & Information Sciences and
Professor, Biological Sciences
Delaware Biotechnology Institute
15 Innovation Way, Suite 205
University of Delaware
Newark, DE 19711

Dear Cathy,

We are pleased about the bioinformatics graduate programs you are proposing. The MS, Professional Science Master's (PSM) and Certificate provide an excellent array of options to meet a variety of student situations and motivations. These programs will also meet a critical need of idustry for trained professionals in our region.

I am especially excited about the Professional Science Master's (PSM) option. As you know, growing and enhancing graduate professional education is one of the milestones of the Path to Prominence. I believe that the PSM in Bioinformatics will be a key component of the University's portfolio of graduate professional education options, and fits very well with our industry, health care and government partnerships.

Sincerely,

John E. Sawyer, Ph.D.
Associate Provost for Professional Education

IX. APPENDIX II

LETTERS OF SUPPORT FROM DEANS OF PARTICIPATING COLLEGES

1. Dr. George H. Watson, Interim Dean, College of Arts & Sciences

2. Dr. Robin W. Morgan, Dean, College of Agriculture & Natural Resources

3. Dr. Michael J. Chajes, Dean, College of Engineering

4. Dr. Nancy M. Targett, Dean, College of Earth, Ocean & Environment

OFFICE OF THE DEAN

4 Kent Way
University of Delaware
Newark, Delaware 19716
Ph: 302/831-2793
Fax: 302/831-6398

November 20, 2009

Cathy H. Wu
Edward G. Jefferson Professor of Bioinformatics & Computational Biology
Department of Computer & Information Sciences
Delaware Biotechnology Institute
University of Delaware

Dear Professor Wu,

The College of Arts & Sciences is pleased to support your applications for three new graduate programs, the Master's of Science in Bioinformatics & Computational Biology, the Professional Science Master's in Bioinformatics, and the Graduate Certificate in Bioinformatics , each with two concentrations, in Computational Sciences Concentration and Life Sciences Concentration. Given the current courses that will taken by students in this program, and our plans to hire additional faculty in the areas of Bioinformatics and Computational Biology, we can provide the instructional capacity needed for this program. We have reviewed the business plan for the PSM program and believe that this can be a sustainable program, even with modest enrollments. The other programs do not require additional fixed costs beyond what we are investing in current programs, so that they should also be sustainable even if they generate no new revenue.

Programs such as these will provide important new educational options for students, serve local companies by offering training opportunities for their employees, make the region more attractive to prospective employers and residents, and enhance the prominence of the University. We strongly support this initiative.

Sincerely,

George H. Watson
Interim Dean

COLLEGE OF AGRICULTURE AND NATURAL RESOURCES

OFFICE OF THE DEAN

Townsend Hall
University of Delaware
Newark, Delaware 19716-2103
Ph: 302/831-2501
Fax: 302/831-6758

UNIVERSITY OF DELAWARE

November 19, 2009

MEMORANDUM

TO: Dr. Cathy H. Wu
        Edward G. Jefferson Chair of Bioinformatics & Computational Biology
        Delaware Biotechnology Institute

FROM: Dr. Robin W. Morgan, Dean
        College of Agriculture and Natural Resources

RE: **Master's program in Bioinformatics and Computational Biology**

The College of Agriculture and Natural Resources is pleased to support the Master's program in Bioinformatics and Computational Biology. You and your colleagues have assembled an impressive program application, and we enthusiastically endorse it.

The College of Agriculture and Natural Resources has invested in bioinformatics to the best of our ability over the past several years, and we are now excited to see this effort escalate. Our faculty who serve on the Bioinformatics Steering Committee and Graduate Committee will be encouraged to participate fully in these efforts, and we will earnestly make our courses that are core or elective courses in the curriculum available to as many students as possible.

This is a great opportunity for the University of Delaware, we look forward to the collaboration this new program offers in the life sciences, and we applaud the standard it sets for similar efforts in other disciplines.

November 19, 2009

Prof. Cathy Wu
Department of Computer & Information Sciences
University of Delaware
Newark, DE   19716

RE: Proposed Master's Program in Bioinformatics & Computational Biology

Dear Cathy,

I am very pleased to be able to provide the support of the College of Engineering for the proposed Master's degree programs—Master of Science in Bioinformatics & Computational Biology (BICB-MS), Professional Science Master's in Bioinformatics (BINF-PSM), and Graduate Certificate in Bioinformatics (BINF-CERT). You have put together an excellent proposal, and there is no doubt that these programs are of extremely high quality. I thank you for your efforts as these programs will be a great addition to our graduate degree offerings here at UD.

We look forward to supporting your efforts as the programs move forward.

Cordially,

Michael J. Chajes, Dean and Professor

COLLEGE OF EARTH, OCEAN, AND ENVIRONMENT

OFFICE OF THE DEAN

111 Robinson Hall
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Newark, DE 19716-3501 U.S.A.
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E-Mail: ntargett@udel.edu
URL: www.ceoe.udel.edu

21 November 2009

Professor Cathy Wu
Delaware Biotechnology Institute
University of Delaware
Newark, DE 19716

Dear Cathy,

I am pleased to strongly endorse the M.S. program that you propose in Bioinformatics and Computational Biology. You have put together a compelling rationale and a very thorough case in support of this new degree program. CEOE, through its relevant programs, is very pleased to be a participant.

Sincerely,

Nancy M. Targett, Ph.D.
Dean

PART V

PROGRAM POLICY STATEMENT

I. PROGRAM HISTORY

A. RATIONALE

The completion of the human genome sequence marked the beginning of a new era of biological research. Scientists have begun to systematically tackle gene functions and other complex regulatory processes by studying organisms at the global scales. Advances in high-throughput biotechnologies and large-scale bioscience have further enabled modeling and simulation over a multitude of length, time and biological scales from biomolecules, cells, tissues and organs to organisms and population. With the enormous volume of data being produced, biology is becoming an increasingly quantitative science. Computational approaches, in combination with experimental methods, have become essential for generating novel hypotheses, deriving new scientific knowledge, and driving discovery and innovation.

Bioinformatics & Computational Biology is an emerging field where biological and computational disciplines converge. According to the National Institutes of Health, the working definitions of Bioinformatics and Computational Biology are as follows:
- *Bioinformatics*: Research, development, or application of computational tools and approaches for expanding the use of biological, medical, behavioral or health data, including those to acquire, store, organize, archive, analyze, or visualize such data.
- *Computational Biology*: The development and application of data-analytical and theoretical methods, mathematical modeling and computational simulation techniques to the study of biological, behavioral, and social systems.

Fundamental to the modern day biological studies and key to the basic understanding of complex biological systems, Bioinformatics & Computational Biology is impacting the science and technology of fields ranging from agricultural and environmental sciences to pharmaceutical and medical sciences. The research requires close collaboration among multi-disciplinary teams of researchers in quantitative sciences, life sciences, and their interfaces.

According to many accredited scientific and industry reviews, bioinformatics and computational biology may well be the single fastest-growing specialty in the life sciences. The University of Delaware currently does not offer a specialized graduate degree in Bioinformatics & Computational Biology, although related courses have been taught in several departments for a number of years. The Master's program in Bioinformatics & Computational Biology will offer graduate education in a discipline essential for UD as a major research university. According to the International Society for Computational Biology, there are presently 180 bioinformatics-related degree programs worldwide, almost 100 in the United States alone.

The Master's program in Bioinformatics & Computational Biology will train the next-generation of researchers and professionals who will play a key role in multi- and interdisciplinary teams, bridging life sciences and computational sciences. The program will be administered through its academic home, the Department of Computer & Information Sciences, and will be coordinated by the newly established Center for Bioinformatics & Computational Biology. The scientific curriculum will build upon the research and educational strength from departments across the Colleges of Arts & Sciences, Engineering, Agriculture & Natural Resources, and Earth, Ocean &

Environment. The Master's program will provide a solid foundation for the future development of a PhD degree program in Bioinformatics and Computational Systems Biology. The program will be synergistic to the existing degree programs, providing a critical component to University's strategic priorities in Energy and Environment studies and Translational Medicine, and serving as a pillar of UD's *Path to Prominence*.

B. DEGREES OFFERED

The Bioinformatics Master's program will offer three degrees—*Master of Science in Bioinformatics & Computational Biology (BICB-MS), Professional Science Master's in Bioinformatics (BINF-PSM),* and *Graduate Certificate in Bioinformatics (BINF-CERT)*. Each degree will have two concentrations—*Computational Sciences Concentration (CS, CS1, CS2)* and *Life Sciences Concentration (LSC, LSC1, LSC2)*. The three degree programs will share the common Bioinformatics & Computational Biology Core (15 credits). The Master of Science (MS) and the Professional Science Master's (PSM) will also share the same Elective courses (6 credits) and Ethic courses (3 credits). The Thesis (6 credits) and Seminars (3 credits) of BICB-MS will prepare students for advanced research, while the immersive Internship of BINF-PSM (6 credits) will provide hands-on real-world experience in research and development. In addition, the BINF-PSM will have a "Plus" component (12 credits) to provide training for professional skills.

Launching the Master's program in Bioinformatics & Computational Biology with six degree options at the same time (Fall 2010) will support students from different educational backgrounds and with different career aspirations, while leveraging the common course curriculum. The students, full-time or part-time, may come from various biological, life sciences background, from computational, quantitative sciences and engineering background, or even from "unconventional" fields such as business, management, law and medicine. They may be interested in applying bioinformatics as an integral approach to life science research and development, or interested in developing new computational methods and bioinformatics tools and databases. Graduates of this program will leave well prepared to pursue careers for research, education, or development in academia, business, industry, government agencies, or non-profit organizations.

B.1. MASTER OF SCIENCES IN BIOINFORMATICS AND COMPUTATIONAL BIOLOGY (BICB-MS)

BICB-MS Degree Requirement	33 Credit Hours Total
Concentrations	Life Sciences
	Computational Sciences
Bioinformatics & Computational Biology Core	15 Credits
Ethics Core	3 Credits
Electives	6 Credits
Thesis	6 Credits
Seminar	3 Credits (1 Credit/Semester, Pass/Fail)

The Master of Science in Bioinformatics & Computational Biology (BICB-MS) will offer graduate education in a discipline essential for UD as a major research university. The BICB-MS

will provide an interdisciplinary program to foster educational and research collaborations across Colleges, increasing UD's competitiveness in interdisciplinary training programs such as NSF's IGERT (Integrative Graduate Education and Research Traineeship Program) and research initiatives such as NIH's CTSA (Clinical and Translational Science Award). The BICB-MS will provide a solid foundation for the future development of a PhD degree program in Bioinformatics and Computational Systems Biology.

The thesis-based BICB-MS degree will prepare students for advanced research. The Computational Sciences Concentration (CS) will allow students with strong quantitative sciences background to gain knowledge and research experience in developing computational methods and bioinformatics tools and databases for the study of biological systems. The Life Sciences Concentration (LSC) will allow students with strong biological background to gain knowledge and research experience in applying bioinformatics methods, tools and databases as an integral approach to life science research. The BICB-MS graduates will have solid knowledge and research experience to pursue further study towards a PhD or other professional degree such as MD, MBA or law, or a research career in academia, industry, or government agencies.

B.2. PROFESSIONAL SCIENCE MASTER'S IN BIOINFORMATICS (BINF-PSM)

BINF-PSM Degree Requirement	42 Credit Hours Total
Concentrations	Life Sciences
	Computational Sciences
Bioinformatics & Computational Biology Core	15 Credits
Ethics Core	3 Credits
Electives	6 Credits
Internship	6 Credits
Professional Science Master's Plus Courses	12 Credits

The Professional Science Master's in Bioinformatics (BINF-PSM) will position UD as a regional leader in bioinformatics professional education. To address the growing need for highly trained professionals in industry, there is a need for an alternative model of graduate education, which is focused on preparing graduates for nonacademic careers. Over the last decade, the concept of Professional Science Master's has crystallized as the most effective response to the observed industry dynamic. The "Plus" component of the BINF-PSM will provide training for professional skills for business/industry or for government/non-profit sectors, such as leadership and organization, project management and operations, managerial decision making, intellectual property, and legal and regulatory affairs. These are the "breadth areas" that top the traditional program's "scientific width", delivering a so-called T-shaped professional.

The scientific curriculum, together with "Plus" component for professional skills and the immersive Internship will prepare the BINF-PSM graduates to pursue a professional career. The Computational Sciences Concentration (CS1) will allow students to gain knowledge and industry experience in developing bioinformatics methods, tools and/or databases for modern biotechnology or medicine. The Life Sciences Concentration (LSC1) will allow students to gain knowledge and industry experience in applying bioinformatics methods, tools and databases as an integral approach to modern biotechnology and medicine. The BINF-PSM graduates will be

well positioned to pursue a professional career in industry, business, government agencies, or non-profit organizations.

B.3. GRADUATE CERTIFICATE IN BIOINFORMATICS (BINF-CERT)

BINF-CERT Degree Requirement	15 Credit Hours Total
Concentrations	Life Sciences
	Computational Sciences
Bioinformatics & Computational Biology Core	15 Credits

The Graduate Certificate in Bioinformatics (BINF-CERT) will provide bioinformatics core competency. Sharing the same Bioinformatics Science Core curriculum, the Certificate is ideally suited for working professionals who cannot make a commitment to the BICB-MS or BINF-PSM program at this time, but can use the Certificate as a stepping stone. The Certificate can also complement other UD degree programs, allowing current graduate students to gain bioinformatics knowledge and skills. The Computational Sciences Concentration (CS2) will allow students to gain knowledge in developing bioinformatics methods, tools and/or databases for modern biotechnology or medicine. The Life Sciences Concentration (LSC2) will allow students to gain knowledge in applying bioinformatics methods, tools and databases as an integral approach to modern biotechnology or medicine.

II. ADMISSION

A. ADMISSION REQUIREMENTS

Admission to the graduate program is competitive. Those who meet stated requirements are not guaranteed admission, nor are those who fail to meet all of those requirements necessarily precluded from admission if they offer other appropriate strengths.

The following are the admission requirements to the Master's program in Bioinformatics & Computational Biology that apply to all three degrees (BICB-MS, BINF-PSM and BINF-CERT):
- A bachelor's degree at an accredited four-year college or university with a minimum grade average of 3.0 on a 4.0 system;
- Applicants may have undergraduate degrees from biological, computational, or other disciplines. However, applicants are expected to have scholarly competence in mathematics, computer science and/or biology;
- The following GRE scores are competitive: Quantitative: 650, Verbal + Quantitative: 1200. No GRE subject test is required;
- International student applicants must demonstrate a satisfactory level of proficiency in the English language if English is not the first language. The University requires an official paper-based TOEFL score of at least 550, at least 213 on the computer-based TOEFL, or at least 79 on the Internet-based TOEFL. TOEFL scores more than two years old cannot be considered official;

- Three letters of recommendation are required. At lease one letter must be from professors, other letters can be from employers or others who have had a supervisory relationship with the applicant and are able to assess the applicant's potential for success in graduate studies; and
- Applications must also include a resume outlining work and academic experience, as well as an application essay consisting of the answers to the following questions:
    1. What educational background and scientific research or employment experience prepare you for this bioinformatics degree program?
    2. What are your long-term professional objectives?
    3. What specific attributes of the bioinformatics program make you feel that this degree is appropriate to help you achieve your professional objectives?

B. APPLICATION

Application to the Master's program in Bioinformatics & Computational Biology will be submitted using the on-line graduate admission application that includes transcripts from all previous college or university study, letters of recommendation, resume, application essay, and official GRE and TOEFL scores (if applicable). If any part of an application is missing, evaluation of the application cannot begin. The applicant will apply to the Department of Computer & Information Sciences.

B.1. APPLICATION DEADLINES

Admission decisions are made on a rolling basis as and when applications are complete. Decisions on financial aid awards are usually made in March-May for the Fall Semester, and in November-December for the Spring Semester. The central graduate admissions office continues to process applications and transcripts throughout the year and follows the stated two (2) week processing timeline for all materials received in the office.

The following are the application deadlines to the Master's program in Bioinformatics & Computational Biology that apply to all three degrees (BICB-MS, BINF-PSM and BINF-CERT):
- Fall Semester: July 1st (regular application); February 1st (financial aid)
- Spring Semester: December 1st (regular application); October 1st (financial aid)

B.2. CHANGE OF CLASSIFICATION

Students currently matriculated in other graduate degree programs should complete a "Change of Classification" Form to seek approval to enter the Master's program in Bioinformatics & Computational Biology. The Bioinformatics Graduate Committee will evaluate each Change of Classification request on a case-by-case basis and determine whether the student is required to submit a completed admission application form to the Office of Graduate and Professional Education and follow the same procedures for admission as other applicants.

Students should also complete a Change of Classification Form for moving within the program, e.g., from BINF-CERT to BICB-MS or BINF-PSM; or from BICB-MS to BINF-PSM. The Bioinformatics Graduate Committee will evaluate and approve the transfer requests on a case-

by-case basis. A student in the BICB-MS program who has been funded on a Graduate Assistantship will require the consent of the Faculty Advisor for transfer to another degree option in the program.

C. ADMISSION STATUS

Students may be admitted into the Master's program in Bioinformatics & Computational Biology with regular status or provisional status.

Regular. Regular status is offered to students who meet all of the established entrance requirements, who have a record of high scholarship in their fields of specialization, and who have the ability, interest, and maturity necessary for successful study at the graduate level in a degree program.

Provisional. Provisional status is offered to students who are seeking admission to the degree program but lack one or more of the specified prerequisites. All provisional requirements must be met within the deadline given before regular status can be granted. Students admitted with provisional status are generally not eligible for assistantships or fellowships. Students who file an application during the final year of undergraduate or current graduate work and are unable to supply complete official transcripts showing the conferral of the degree will be admitted pending conferral of the degree if their records are otherwise satisfactory and complete. For students lacking appropriate preparatory course work, additional courses applicable to certain areas of study may be required prior to admission or students may be admitted with the provision that completion of certain area content courses be completed concurrent with the courses in the degree program.

III. ACADEMIC

A. DEGREE REQUIREMENTS

The tables below list the degree requirements for each of the three degrees—Master of Science in Bioinformatics & Computational Biology (BICB-MS), Professional Science Master's in Bioinformatics (PSM-BINF), and Graduate Certificate in Bioinformatics (BINF-CERT), with the respective concentrations—Computational Sciences Concentration and Life Sciences Concentration.

1. **MASTER OF SCIENCE IN BIOINFORMATICS AND COMPUTATIONAL BIOLOGY: COMPUTATIONAL SCIENCES CONCENTRATION**

BICB-MS Computational Sciences Concentration (CS) – Degree Requirement	
33 Credit Hours Total	
Bioinformatics & Computational Biology Core – Computational Sciences	15 Credits
Ethics Core	3 Credits

Electives – Computational Sciences	6 Credits
Thesis	6 Credits
Seminar	3 Credits (1 Credit/Semester, P/F)

2. MASTER OF SCIENCE IN BIOINFORMATICS AND COMPUTATIONAL BIOLOGY: LIFE SCIENCES CONCENTRATION

BICB-MS Life Sciences Concentration (LSC) – Degree Requirement	
33 Credit Hours Total	
Bioinformatics & Computational Biology Core – Life Sciences	15 Credits
Ethics Core	3 Credits
Electives – Life Sciences	6 Credits
Thesis	6 Credits
Seminar	3 Credits (1 Credit/Semester, P/F)

3. PROFESSIONAL SCIENCE MASTER'S IN BIOINFORMATICS: COMPUTATIONAL SCIENCES CONCENTRATION

BINF-PSM Computational Sciences Concentration (CS1) – Degree Requirement	
42 Credit Hours Total	
Bioinformatics & Computational Biology Core – Computational Sciences	15 Credits
Ethics Core	3 Credits
Electives – Computational Sciences	6 Credits
Internship	6 Credits
Professional Science Master's Plus Courses (Business/ industry Track or Government/Non-Profit Track)	12 Credits

4. PROFESSIONAL SCIENCE MASTER'S IN BIOINFORMATICS: LIFE SCIENCES CONCENTRATION

BINF-PSM Life Sciences Concentration (LSC1) – Degree Requirement	
42 Credit Hours Total	
Bioinformatics & Computational Biology Core – Life Sciences	15 Credits
Ethics Core	3 Credits
Electives – Life Sciences	6 Credits
Internship	6 Credits
Professional Science Master's Plus Courses (Business/ industry Track or Government/Non-Profit Track)	12 Credits

5. GRADUATE CERTIFICATE IN BIOINFORMATICS: COMPUTATIONAL SCIENCES CONCENTRATION

BINF-CERT: Computational Sciences Concentration (CS2) – Degree Requirement

15 Credit Hours Total	
Bioinformatics & Computational Biology Core – Computational Sciences	15 Credits

6. GRADUATE CERTIFICATE IN BIOINFORMATICS: LIFE SCIENCES CONCENTRATION

BINF-CERT: Life Sciences Concentration (LSC2) – Degree Requirement	
15 Credit Hours Total	
Bioinformatics & Computational Biology Core – Life Sciences	15 Credits

B. COURSE CURRICULUM

The tables below list the course curriculum for the major components of the Master's program in Bioinformatics & Computational Biology. New or revised courses required for the curriculum are marked. All of these courses have been submitted to the Course Challenge list and will be effective for the Fall 2010 term.

1. BIOINFORMATICS SCIENCE CORE – COMPUTATIONAL SCIENCES

Bioinformatics & Computational Biology Core – Computational Sciences (15)	
Bioinformatics (3)	CISC636: Bioinformatics (3) *
Introduction to Discipline (3) [select one]	ELEG671: Introduction to Biomedical Engineering (3)
	BISC602: Molecular Biology of Animal Cells (3)
	BISC612: Advanced Cell Biology (3)
	BISC654: Biochemical Genetics (3)
	PLSC636: Plant Genes and Genomes (3) *
	ANFS670: Principles of Molecular Genetics (3)
	MAST616: Methods in Molecular Biology (3)
Systems Biology (3)	MATH560: Introduction to Systems Biology (3) *
Database (3)	CISC637: Database Systems (3)
Biostatistics (3) [select one]	STAT613: Multivariate Statistical Methods with Biology Applications (3) *
	STAT656: Biostatistics (3)

CISC636: Bioinformatics (3) * submitted for re-title from "Introduction to Bioinformatics"
PLSC636: Plant Genes and Genomes (3) * submitted for re-title from "Advanced Plant Genetics"
MATH560: Introduction to Systems Biology (3) * adapted from MATH460
STAT613: Multivariate Statistical Methods with Biology Applications (3) * new course being developed

2. BIOINFORMATICS SCIENCE CORE – LIFE SCIENCES

Bioinformatics & Computational Biology Core – Life Sciences (15)	
Bioinformatics (3)	ANFS644: Bioinformatics
Introduction to Discipline (3)	MAST697: Bioinformatics Programming for Biologists *
Systems Biology (3)	MAST698: Environmental and Systems Bioinformatics *
Database (3)	CISC637: Database Systems (3)

Biostatistics (3)	STAT613: Multivariate Statistical Methods with Biology Applications (3) *
[select one]	STAT656: Biostatistics (3)

MAST697: Bioinformatics Programming for Biologists (3) * submitted for permanent status
MAST698: Environmental and Systems Bioinformatics (3) * submitted for permanent status
STAT613: Multivariate Statistical Methods with Biology Applications (3) * new course being developed

3. ETHICS CORE

Ethics Core (3)	
Ethics (3) [select one]	BISC631: Practice of Science (3)
	UAPP648: Environmental Ethics (3)
	UAPP650: Values Ethics and Leadership (3)
	BUAD840: Ethical Issues in Global Business Environments (3)

4. BIOINFORMATICS & COMPUTATIONAL BIOLOGY INTERNSHIP/SEMINAR/THESIS

Internship (6)	
Internship (6)	BINF864: Internship (1-6) *
Seminar (3)	
Seminar [3 semesters]	BINF865: Seminar (1) *
Thesis (6)	
Thesis (6)	BINF869: Master's Thesis (1-6) *

BINF864: Internship * new course listing
BINF865: Seminar * new course listing
BINF869: Master's Thesis * new course listing

5. ELECTIVES – COMPUTATIONAL SCIENCES

Electives – Computational Sciences (6)	
Electives (6) [select two]	CISC841: Algorithms in Bioinformatics (3)
	CISC621: Algorithm Design and Analysis (3)
	CISC640: Computer Graphics (3)
	CISC642: Introduction to Computer Vision (3)
	CISC650: Computer Networks (3)
	CISC675: Object Oriented Software Engineering (3)
	CISC681: Artificial Intelligence (3)
	CISC683: Introduction to Data mining (3)
	CISC882: Natural Language Processing (3)
	CISC886: Multi-Agent Systems (3)
	CISC887: Internet Information Gathering (3)
	CISC888: Machine Learning (3)
	MATH607: Survey of Scientific Computing (3)
	MATH611: Introduction to Numerical Analysis and Scientific Computing (3)
	STAT670: Introduction to Statistical Analysis I (3) *
	STAT671: Introduction to Statistical Analysis II (3) *
	STAT608: Statistical Research Methods (3)
	STAT615: Design and Analysis of Experiments (3)

	STAT619: Time Series Analysis (3)
	STAT621: Survival analysis (3)
	STAT674: Applied Data Base Management (3)
	ELEG633: Image Processing (3)
	ELEG652: Principles of Parallel Computer Architectures (3)
	ELEG655: High-Performance Computing with Commodity Hardware (3)
	ELEG679: Introduction to Medical Imaging Systems (3)
	ELEG680: Immunology for Engineers (3)
	CHEG620: Biochemical Engineering (3)
	CHEG621: Metabolic Engineering (3)

STAT670: Introduction to Statistical Analysis I (3) * new course being developed
STAT671: Introduction to Statistical Analysis II (3) * new course being developed

6. ELECTIVES – LIFE SCIENCES

Electives – Life Sciences (6)	
Electives (6) [select two]	BISC600: Biotechnology and Molecular Medicine (3)
	BISC602: Molecular Biology of Animal Cells (3)
	BISC605 Advanced mammalian physiology (4)
	BISC612: Advanced Cell Biology (3)
	BISC615 Vertebrate Developmental Biology (3)
	BICS625: Cancer Biology (3)
	BISC641: Microbial Ecology (3)
	BISC645: Bacterial Evolution (3)
	BISC654: Biochemical Genetics (3)
	BISC656: Evolutionary Genetics (3)
	BISC665: Advanced Molecular Biology & Genetics (3)
	BISC671: Cellular and Molecular Immunology (3)
	BISC675 Cardiovascular Physiology (3)
	BISC679: Virology (3)
	BISC682: Bacterial Pathogens: Molecular Mechanisms (3)
	BISC693: Human Genetics (3)
	STAT670: Introduction to Statistical Analysis I (3) *
	STAT671: Introduction to Statistical Analysis II (3) *
	CHEM624: Principles of Mass Spectrometry (3)
	CHEM641: Biochemistry (3)
	CHEM645: Protein Structure and Function (3)
	CHEM646: DNA-Protein Interactions (3)
	CHEM649: Molecular Biophysics (3)
	ANFS670: Principles of Molecular Genetics (3)
	MAST616: Methods in Molecular Biology (3)
	MAST618: Marine Microbial Ecology (3)
	MAST623: Physiology of Marine Organisms (3)
	MAST625: Microbial Physiology and Diversity (3)
	MAST634: Marine Molecular Sciences (3)
	PLSC636: Plant Genes and Genomes (3) *
	PLSC644: Physiology of Plant Stress (3)

	HESC602: Data Analysis and Interpretation in Health Sciences (3)
	HESC654: Medical Physiology (3)
	PHYT606: Research (3)
	PHYT623: Clinical Neuroscience (4)
	PHYT633: Applied Physiology II (3)

STAT670: Introduction to Statistical Analysis I (3) * new course being developed
STAT671: Introduction to Statistical Analysis II (3) * new course being developed

7. PROFESSIONAL SCIENCE MASTER'S PLUS COURSES

Professional Science Master's Plus Courses – Business/Industry Track † (12)	
Survey of Business (3)	BUAD500: Survey of Business (3) *
Leadership and Organization (3)	BUAD870: Leadership and Organizational Behavior (3)
Project Management, Operations or Entrepreneurship (3) [select one]	BUAD831: Operations Management and Management Science (3)
	BUAD835: Managing New Product Development Projects (3)
	BUAD871: Managing for Creativity and Innovation (3)
	ENTR860: High Technology Entrepreneurship (3)
	MISY840: Project Management and Costing (3)
Intellectual Property (3)	CHEG595: Intellectual Property for Engineers and Scientists (3)
Professional Science Master's Plus Courses – Government/Non-Profit Track † (12)	
Survey of Public Administration(3)	UAPP803: Seminar in Public Administration (3)
Leadership and Organization (3) [select one]	UAPP835: Organization and Management (3)
	UAPP604: Leadership in Organizations (3)
Managerial Decision Making or Financial Management (3) [select one]	UAPP819: Management Decision Making in Public & Nonprofit Sectors (3)
	UAPP833: Financial Management in Public & Nonprofit Sectors (3)
	UAPP827: Program and Project Analysis (3)
	UAPP829: Taxation and Fiscal Policies (3)
Legal and Regulatory Affairs (3)	UAPP646: Administrative Law and Policy (3)

BUAD500: Survey of Business (3) * new course being developed
† Students are recommended to follow one of the tracks, but may cross over tracks to fit interest.

C. COMMITTEES AND DIRECTOR

The development, administration and progress assessment of the overall Master's program in Bioinformatics & Computational Biology (covering all six degrees options) will be guided by the Director and three committees—the Bioinformatics Steering Committee, the Bioinformatics Industry Advisory Board and the Bioinformatics Graduate Committee, as outlined below.

C.1. BIOINFORMATICS STEERING COMMITTEE

The Steering Committee will advise the development and progress assessment of the Master's program in Bioinformatics & Computational Biology. The committee consists of faculty members from all ten Departments across four Colleges participating in this degree program.

Member	College	Department	Expertise
Wu, Cathy (Chair)	Arts & Science	Computer & Information Sciences	Bioinformatics, Cyberinfrastrcture
Antoniewicz, Maciek	Engineering	Chemical Engineering	Metabolic Engineering, Systems Biology
Bahnson, Brian	Arts & Science	Chemistry & Biochemistry	Structure Biology, Molecular Modeling
Duncan, Melinda	Arts & Science	Biological Sciences	Biotechnology PSM, Developmental Biology
Hanson, Thomas	Earth, Ocean & Environment	Marine Biosciences	Microbial Genomics
Lee, Kelvin	Engineering	Chemical Engineering	Systems Biology, Proteomics
Liao, Li	Arts & Science	Computer & Information Sciences	Bioinformatics and Computational Biology
Marsh, Adam	Earth, Ocean & Environment	Marine Biosciences	Environmental Bioinformatics
Meyers, Blake	Agriculture & Natural Resources	Plant & Soil Sciences	Plant Genomics, Bioinformatics
Rejto, Lidia	Agriculture & Natural Resources	Food & Resource Economics	Biostatistics
Schleiniger, Gilberto	Arts & Science	Mathematical Sciences	Quantitative Biology BS Major, Mathematical Biology
Schmidt, Carl	Agriculture & Natural Resources	Animal & Food Sciences	Avian Genomics
Taufer, Michaela	Arts & Science	Computer & Information Sciences	Grid Computing, Cloud Computing
Wommack, Eric	Agriculture & Natural Resources	Plant & Soil Sciences	Viral Genomics
Zurakowski, Ryan	Engineering	Electrical & Computer Engineering	Biomedical Engineering

C.2. BIOINFORMATICS INDUSTRY ADVISORY BOARD

The Industry Advisory Board will advise the development and progress assessment of the Master's program in Bioinformatics & Computational Biology from industry perspectives. The Board consists of representatives from major regional companies and institutions who will participate in this degree program and have committed to host internships.

Member	Title	Organization
Tomb, Jean-Francois (Chair)	Manager – Bioinformatics at DuPont	DuPont Central Research & Development
Barbara, Deb	VP, New Business Development	Strategic Diagnostics, Inc.
Bunnell, Tim	Director, Center for Pediatric Auditory & Speech Sciences	duPont Hospital for Children
Christianson,	Director of Discovery Medicine	AstraZeneca

Anastasia	Informatics	
Foutrakis, George	Associate, GORE Medical Products	W.L. Gore
Hollis, Greg	VP, Applied Technology Group	Incyte
Weintraub, William	Director, Christiana Center for Outcomes Research	Christiana Care
Wright, Ian	Head of Global Assay Development	Siemens Healthcare Diagnostics

C.3. BIOINFORMATICS GRADUATE COMMITTEE

The Graduate Committee will be responsible for admission, advising, and progress assessment of the students in the Master's program in Bioinformatics & Computational Biology, working closely with the students' Faculty Advisors. The committee consists of at least two representative faculty members from each participating College in this degree program.

Member	College	Department
Wu, Cathy (Chair)	Arts & Sciences	Computer & Information Sciences/ Biological Science
Hanson, Thomas	Earth, Ocean & Environment	Marine Biosciences
Lee, Kelvin	Engineering	Chemical Engineering
Liao, Li	Arts & Sciences	Computer & Information Sciences
Papoutsakis, Eleftherios	Engineering	Chemical Engineering
Patel, Sandeep	Arts & Sciences	Chemistry & Biochemistry
Rejto, Lidia	Agriculture & Natural Resources	Food & Resource Economics
Schleiniger, Gilberto	Arts & Sciences	Mathematical Sciences
Schmidt, Carl	Agriculture & Natural Resources	Animal & Food Sciences
Wommack, Eric	Agriculture & Natural Resources/ Earth, Ocean & Environment	Plant and Soil Sciences/ Marine Biosciences

C.4. DIRECTOR

The Director of the Master's program in Bioinformatics & Computational Biology will be responsible for the overall implementation, quality and progress of the degree program, advised by the Steering Committee and the Industry Advisory Board. The Director will also be the Chair of the Bioinformatics Graduate Committee. We propose that the Director of the Master's program in Bioinformatics & Computational Biology be a rotating position. Because of a significant amount of time and effort spent in starting up the program, we propose that the Director be located in Computer & Information Sciences for the first two years to get things started. Then, the position will rotate for a three-year term. The Director may appoint a Coordinator to provide day-to-day program management and assist with student recruitment, admission, advising, progress assessment, and career planning.

D. SATISFACTORY PROGRESS

D.1. FACULTY ADVISOR

Students are required to choose an appropriate Faculty Advisor from a list of faculty members participating in the degree program or have an appropriate Faculty Advisor appointed by the Director of the Master's program in Bioinformatics & Computational Biology. The participating faculty members are faculty approved by the Bioinformatics Steering Committee to advise students and/or serve as research mentors or co-mentors. The list of participating faculty, along with their departments and research interests, are available from the Bioinformatics program web site (http://bioinformatics.udel.edu/Education).

The Faculty Advisor will be the primary contact of the student for questions and advice. The student will develop a plan of study for the program with the Faculty Advisor before the beginning of the second semester. The Director of the Master's program in Bioinformatics & Computational Biology will verify that the student has completed the requirements for the program and will approve the application for the degree upon successful completion of the requirements.

D.2. ACADEMIC LOAD

Full-time student is expected to complete the BICB-MS program (33 credits) or BINF-PSM program (42 credits) in two years. The program may be completed over a longer time frame for part-time students. The BINF-CERT program (15 credits) can be completed in one year, or longer on a part-time basis.

Students enrolled in at least 9 credit hours or in sustaining credit are considered full-time students. Those enrolled for fewer than 9 credit hours are considered part-time students, although students holding assistantships are considered full-time with six credits. Generally, a maximum load is 12 graduate credit hours; however, additional credit hours may be taken with the approval of the student's adviser and the Office of Graduate and Professional Education. A maximum course load in either summer or winter session is 7 credit hours. Permission must be obtained from the Office of Graduate and Professional Education to carry an overload in any session

D.3. TRANSFERABILITY

Prior to admission to the Master's program in Bioinformatics & Computational Biology, a prospective student from another institution can be approved by the Bioinformatics Graduate Committee to take up to 9 graduate credits that, if/when admitted to the degree program, would be applied to that degree. Once the student has successfully completed 9 approved graduate UD credits and been admitted to the degree program, then a maximum of 9 graduate credits, but not the grades or quality points, can be transferred into the Master's program from another institution with the approval of the Graduate Committee.

Students who complete graduate credits with the classification of CEND (Continuing Education Non-degree) at the University of Delaware may use a maximum of 9 graduate credits earned with this classification toward their graduate degree.

All requests for transfer credit should be directed to the academic home department, Department of Computer & Information Sciences, using a "Request for Transfer of Graduate Credit" Form.

Transfer credits will be accepted provided that such credits: (i) were earned with a grade of no less than B-, (ii) are approved by the Bioinformatics Graduate Committee, (iii) are in accord with the Program Policy Statement of the Master's program in Bioinformatics & Computational Biology, (iv) are not older than five years, (v) are graduate level courses, and (vi) were completed at an accredited college or university. Graduate courses counted toward a degree received elsewhere may not be transferred into a degree at UD. Credits from institutions outside of the United States are generally not transferable to UD.

D.4. MASTER'S THESIS

The master's thesis of the BICB-MS program will be in most cases completed at the University of Delaware supervised by the Thesis Faculty Advisor. Unless special permission is granted, students need to complete 12 credit hours prior to the start of their internship. Each student working on a master's thesis, with the advice of the Thesis Faculty Advisor, needs to establish a Thesis Committee. The Committee should consist of 3 at least three faculty members, the composition of which should be approved by the Bioinformatics Graduate Committee. The Committee Chair should be the Thesis Faculty Advisor and a participating faculty member in the degree program. At least one other member should be a participating faculty member in the program.

Students, with the assistance of their Thesis Faculty Advisor, will prepare and present a research proposal to their Thesis Committee for review and approval of the proposed research project. Following completion of the research outlined in the proposal, the MS degree candidate will prepare a written thesis according to the guidelines set forth by the Office of Graduate and Professional Education. Upon completion of the master's thesis, a final oral examination must be passed, consisting of a seminar and a defense of the master's thesis. The final oral examination will be directed and evaluated by the student's Thesis Committee.

D.5. PSM INTERNSHIP

The PSM-BINF programs require a 6 month full-time, or a 12 month half-time internship as part of the degree requirements. The capstone internship will be in most cases completed at participating companies/institutions in the Master's program in Bioinformatics & Computational Biology. Most internship opportunities will be in industries based near UD including locations in Delaware, Southeastern Pennsylvania, Northeastern Maryland and Southern New Jersey. However, since these internships can be full time, students may chose to pursue internships further afield as opportunities arise. The internship will be jointly supervised by a Faculty Advisor at UD and an Internship Mentor in the hosting institution. Unless special permission is granted, students need to complete 12 credit hours prior to the start of their internship.

The students, with the assistance of their Faculty Advisor and Internship Mentor, will propose a specific research learning experience for their internship, and have the internship approved by the Director of the Master's program in Bioinformatics & Computational Biology prior to the start of the internship. The internship research will be assessed by the quality of the work performed at the internship, two written reports—a plan of work and a final research paper, as well as a poster presentation. The plan of work should outline the background of the research

project, the learning objectives for the internship and goals to be accomplished. The final 20-page research paper should outline the objectives of internship research, what are accomplished on each objective and recommendations for future work, following the format: Introduction, Research Methods, Results, Discussion/Conclusion, and Reference Citation. The poster presentation will be presented at an annual Research Day at the University of Delaware where MS and PSM students will showcase their thesis and internship projects. The internship will have the same academic rigor of a master thesis, while the emphasis will be on effective problem solving, technological transfer, product development and technical innovation in a team environment at the company setting. The final grade will be assigned by the Faculty Advisor in accordance with UD academic standards.

D.6. GRADE REQUIREMENTS

Only graduate courses completed with a grade of B or higher count towards the requirements of Bioinformatics Master's program. Students receiving a B- or lower in a required core course are subject to dismissal from the program. However, they may file an appeal to the Bioinformatics Graduate Committee for approval to retake the course and remain in the program if the appeal is approved. Students must obtain at least a 3.0 cumulative grade point average in the courses in the curriculum to receive the degree.

D.7. CONSEQUENCES OF UNSATISFACTORY ACADEMIC PROGRESS

The Bioinformatics Graduate Committee will meet at least once each semester to evaluate each student's progress. If a student is failing to make satisfactory progress towards a degree, the committee will recommend suitable action to the Director of the Master's program in Bioinformatics & Computational Biology. Possible actions include (but are not limited to): (i) requirement for additional courses, (ii) suspension of financial support, and (iii) recommendation for dismissal.

D.8. STANDARDS OF STUDENT CONDUCT

All graduate students are subject to University of Delaware regulations regarding academic honesty. Violations of the UD regulations regarding academic honesty or other forms of gross misconduct may result in immediate dismissal from the Program.

D.9. DISMISSAL

The procedures for dismissal as detailed in the University Catalog will be followed. Briefly, the Graduate Committee will report its recommendation and reason for dismissal to the Director of the Bioinformatics Master's program. The Director will make a recommendation to the Office of Graduate Studies, who will decide whether to dismiss the student. The student may appeal this decision to the Office of Graduate Studies, following the procedure given in the University Catalog.

D.10. GRADUATE STUDENT GRIEVANCE PROCEDURES

Students who feel that they have been graded inappropriately or receive what they perceive as an unfair evaluation by a faculty member may file grievances in accordance with University of Delaware policies. Students are encouraged to contact the Director of the Bioinformatics Master's program prior to filing a formal grievance in an effort to resolve the situation informally.

D.11. ATTENDANCE AT CONFERENCES AND PROFESSIONAL MEETINGS

The Bioinformatics Master's program encourages students to attend conferences and professional meetings. They provide opportunities to meet future employers and colleagues, and can offer specialized training beyond course work.

IV. FINANCIAL AID

A. FINANCIAL AWARDS

Admission to the Master's program in Bioinformatics & Computational Biology does not automatically entitle an applicant to financial aid. Students may seek financial aid opportunities, such as fellowships or scholarships from sources within the University and from private and federal agencies. Interested students should check the Office of Graduate Studies for the most current opportunities.

Financial aid is awarded on a competitive basis from the pool of admitted applicants. The University of Delaware's policies apply to all forms of financial aid. Please refer to the University Policies for Graduate Student Assistantships and Fellowships.

Students in the BICB-MS program may apply for the Graduate Assistantships:
- **Research Assistantships (RAs)** are generally funded by research grants and contracts provided by external funding agencies. Students may be supported as an RA through their Faculty Advisor's research funds after their first year. A research assistantship provides full tuition and a stipend. The RA's advisor is responsible for defining the student's responsibilities and for evaluating the student's performance. The amount of service or research may vary from week to week but the average is usually expected to be 20 hours per week.
- **Teaching Assistantships (TAs)** are offered for graduate students to perform teaching and other instructional activities. The amount of service may vary from week to week but the average is usually expected to be 20 hours per week. A teaching assistantship provides full tuition and a stipend. In accordance with University of Delaware regulations, foreign students must achieve a TOEFL score of at least 600 (paper-based), 250 (computer-based), or 100 (Internet-based) in order to qualify for teaching assistantships.

Students in the BINF-PSM program may apply for **Industry Internships**. Paid internships may be available from industry, government agencies or other participating institutions in the Master's program in Bioinformatics & Computational Biology.

B. CONTINUATION OF FINANCIAL AID

Students who are awarded financial aid must maintain satisfactory academic progress with satisfactory performance of assistantship duties (when applicable). Satisfactory academic progress includes registering for a minimum of 9 graduate-level credits each Fall and Spring semester, and maintaining a minimum 3.0 GPA.

The RA's responsibilities and performance standards will be established by the Faculty Advisor. In the event of an unsatisfactory performance by an RA, the advisor will notify the student and the Graduate Committee at least four weeks prior to terminating the assistantship.

The TA's responsibilities and performance standards will be established by the Director of the course in which the student teaches. In the event of an unsatisfactory performance by a TA, the Course Director will notify the student and the Graduate Committee of the academic department offering the course. The Committee may recommend termination of the assistantship to the Department Chair.