MSBS IN BIOINFORMATICS AND PROTEOMICS-GENOMICS

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The Bioinformatics and Proteomics/Genomics (BPG) Programs are designed to provide training in the rapidly-developing interface between computer science and life sciences. Graduates with such training are in high demand, (in part due to the explosion in genome sequence analysis), whether the BPG studies are for an independent degree or for one of the several dual-degree programs. In addition, students in other programs may take BPG courses as electives.

Masters, Certificate and Dual Degree Programs

The program in Bioinformatics and Proteomics/Genomics, along with the Ohio Center of Excellence for Biomarker Research and Individualized Medicine at the University of Toledo, offers a Certificate that can be earned either alone or in association with the degrees of Doctor of Philosophy (PhD) or Doctor of Medicine (MD). The Certificate program is designed to fit smoothly into the doctoral programs with minimal extra time required. BPG also offers a Master of Science in Biomedical Sciences (MSBS) degree. MSBS students follow a well-defined curriculum that includes core courses, journal club, seminars, independent research, and electives in their area of interest. Both Certificate and MSBS students are trained in the theory, methods and applications of bioinformatics, proteomics, genomics, and biomarker research.

Bioinformatics programs generally place more emphasis on either computer science or the biomedical aspects of the field. The University of Toledo's program falls into the latter category. However, there are courses in PERL, Java, and SQL programming (for example), and the Program provides biomedical researchers with a solid introduction to the computational aspects, or computer science experts with a rigorous introduction to the biomedical aspects of bioinformatics.

To be admitted to the Masters in Biomedical Sciences Program with Regular status, applicants must hold an earned baccalaureate (or equivalent) from an accredited college or university. Students with a GPA below 3.0, but at or above 2.5, may apply for provisional acceptance that would change to regular (non-probationary) status if their first term graduate coursework has a GPA of 3.0 or above. Typically, applicants will have an undergraduate major in Biology or a related discipline such as Biochemistry or Biophysics. Students with other majors are encouraged to apply; however, their coursework should include several semesters in biology. The GRE is not required . For international applicants, the Test of English as a Foreign Language (TOEFL) is required. Scores must be 550 or higher for paper-administered version, 213 or higher for computer-administered version, and 80 or higher for internet-administered version. For all applicants, laboratory research or computer programming experience is favored, but not required.

MSBS in Bioinformatics and Proteomics-Genomics Requirements

Code	Title	Hours
BMSP 6340	Curr Prob Res App Genes/Genom	2
BIPG 5100	Fund Bioinformatics Proteomics	3
BIPG 5200	Statistical Methods in Bioinformatics	3
BMSP 6390	Mentored Research	1
BIPG 6100	Bioinformatic Computation	3
BIPG 6400	Applications of Bioinformatics	3
BRIM 6200	Biomarker Disc,Valid & Impleme	3
BMSP 6350	Cell Biology & Signaling	3
BIPG 5400	Biodatabases	1
INDI 6020	On Being a Scientist	1
BIPG 5500	Mining Omics Data	1
BIPG 6990	Thesis in Bioinformatics	1-9
BIPG 5300	Current Topics in BPG	1

Biomedical Science: Bioinformatics and Proteomics-Genomic, MSBS -Clinical Bioinformatics Concentration Requirements

Code	Title	Hours
BMSP 6340	Curr Prob Res App Genes/Genom	2
BMSP 6390	Mentored Research (2x5 week lab rotations)	1
BIPG 5200	Statistical Methods in Bioinformatics	3
BIPG 5100	Fund Bioinformatics Proteomics	3
BIPG 6400	Applications of Bioinformatics	3
BRIM 6200	Biomarker Disc,Valid & Impleme	3
BIPG 6500	Applied Statistics for Bioinformatics	3
BIPG 5400	Biodatabases	1
BIPG 5120	Clinical Bioinformatics	3
INDI 6020	On Being a Scientist	1
BIPG 6110	Case Studies in Omics Medicine	1
BIPG 5300	Current Topics in BPG	1
BIPG 6990	Thesis in Bioinformatics	11
or INDI 6980	Scholarly Project for Medical Sciences	
Electives		6
BIPG 6100	Bioinformatic Computation	
BMSP 6350	Cell Biology & Signaling	
BIPG 6300	Clinical Proteomics	
PUBH 6060	Advanced Biostatistics	
PUBH 6070	Genetic Epidemiology	
PUBH 6130	Molecular Epidemiology	
PUBH 6150	Clinical Epidemiology	
Total Hours		**42**

MSBS in Bioinformatics and Proteomics-Genomics

(CPRA = Current Problems & Research Approaches)
(BIPG = Bioinformatics & Proteomics/Genomics)

First Term		Hours
BMSP 6340	Curr Prob Res App Genes/Genom (8 weeks) [1]	2
BIPG 5200	Statistical Methods in Bioinformatics (16 weeks)	3
BIPG 5100	Fund Bioinformatics Proteomics (16 weeks)	3
BMSP 6390	Mentored Research (10 weeks; 2 x 5 wk lab rotations) [2]	1
	Hours	**9**
Second Term		
BIPG 6100	Bioinformatic Computation (16 weeks)	3
BIPG 6400	Applications of Bioinformatics (16 weeks)	3
or		
BRIM 6200	Biomarker Disc,Valid & Impleme	
BMSP 6350	Cell Biology & Signaling (16 weeks)	3
	Hours	**9**
Third Term		
BIPG 5400	Biodatabases (4 weeks)	1
INDI 6020	On Being a Scientist	1
BIPG 5500	Mining Omics Data (4 weeks)	1
BIPG 6990	Thesis in Bioinformatics [3]	3
	Hours	**6**
Fourth Term		
Elective 2 (see approved list)		3
BIPG 5300	Current Topics in BPG (16 weeks) [4]	1
BIPG 6990	Thesis in Bioinformatics	5
	Hours	**9**
Fifth Term		
Elective 2 (see approved list)		3
BIPG 6990	Thesis in Bioinformatics	6
	Hours	**9**
Sixth Term		
	Hours	**0**
	Total Hours	**42**

1 CPRA = Current Problems & Research Approaches.

2 Students must register for a specific 10 wk/1 cr section of BMSP 6390 Mentored Research for 2 five-week rotations. As a prerequisite, students must attend an introductory series of short research presentations "Introduction to Biomedical Research". These presentations do not require students to register, but BIPG students are expected to attend for the first 3-4 weeks of the Fall semester.

3 Students must pass Qualifying Exam before registering for BIPG 6990 Thesis research. In this and other terms, with permission of advisory committee, student may take Scholarly Project in BIPG (BIPG5900) in place of Thesis in Bioinformatics.

4 Journal paper review and presentation.

The minimum number of credits required for MSBS is 42, with a minimum of 20 credits of didactic coursework (letter grade), and a minimum of 10 credits of thesis research. The rest of the credits are approved electives and research in the BIPG track.

Biomedical Science: Bioinformatics And Proteomics-Genomic, MSBS -Clinical Bioinformatics Concentration

First Year

First Term		Hours
BMSP 6340	Curr Prob Res App Genes/Genom	2
BIPG 5200	Statistical Methods in Bioinformatics	3
BIPG 5100	Fund Bioinformatics Proteomics	3
BMSP 6390	Mentored Research (2x5 week lab rotations)	1
	Hours	**9**
Second Term		
BIPG 6400 or BRIM 6200	Applications of Bioinformatics (OR) or Biomarker Disc,Valid & Impleme	3
BIPG 6500	Applied Statistics for Bioinformatics	3
Elective (choose one 3-credit elective from elective list)		3
	Hours	**9**
Third Term		
BIPG 5400	Biodatabases	1
BIPG 5120	Clinical Bioinformatics	3
INDI 6020	On Being a Scientist	1
BIPG 6110	Case Studies in Omics Medicine	1
must pass QE by end of year 1		
	Hours	**6**
Fourth Term		
BIPG 5300	Current Topics in BPG	1
BIPG 6990 or INDI 6980	Thesis in Bioinformatics (Or) or Scholarly Project for Medical Sciences	5
Elective		3
	Hours	**9**
Fifth Term		
BIPG 6990 or INDI 6980	Thesis in Bioinformatics (Or) or Scholarly Project for Medical Sciences	6
BIPG 6400 or BIPG 6200	Applications of Bioinformatics or Advanced Programming in Bioinformatics	3
	Hours	**9**
	Total Hours	**42**

MSBS in Bioinformatics and Proteomics-Genomics Learning Outcomes

- PLO 1. K1 Knowledge of molecular, biochemical, and cellular mechanisms involved in regulation of cellular processes and development.
- PLO 2. K2 Knowledge of fundamental systems biology technologies, such as proteomics, genomics and transcriptomics.

- PLO 3. K3 Knowledge of algorithmic and statistical methods for analysis of nucleic acid and protein sequences, such as hidden Markov models and Bayesian statistics.
- PLO 4. K4 Knowledge of at least one modern computer programming language, such as PERL.
- PLO 5. K5 Knowledge of database design and management.
- PLO 6. K6 Knowledge of the principles and legal responsibilities that govern responsible conduct of research, and the accurate reporting of research results.
- PLO 7. S1 The ability to perform procedures necessary for the completion of the student's thesis (M.S.) research project(s).
- PLO 8. S2 The ability to design and complete an independent research project.
- PLO 9. S3 The ability to assess statistical and biological significance of bioinformatic results and patterns.
- PLO 10. S4 The ability to perform research productively as an individual or member of a research team.
- PLO 11. S5 The ability to communicate research findings effectively, both orally and in writing.
- PLO 12. S6 The ability to use electronic databases via automated scripting.
- PLO 13. S7 The ability to retrieve biomedical information for solving problems that are relevant to the appropriate completion of a research project, and accurate reporting of the results.
- PLO 14. P1 Ethical, responsible, and reliable behavior in all aspects of their professional lives.
- PLO 15. P2 Honesty and integrity in all interactions with colleagues, research subjects, and others with whom students may interact in their professional lives.
- PLO 16. P3 Professionalism in dress and grooming in compliance with health and safety rules applicable to research laboratories and to other institutional and public sites.
- PLO 17. P4 Respect of and adherence to all laws and regulations governing the biomedical research use of animals and patient materials, and for all patient privacy issues.
- PLO 18. P5 Respect of and adherence to all laws and regulations governing ethical use of computers and remote computational facilities.

Biomedical Science: Bioinformatics and Proteomics-Genomic, MSBS -Clinical Bioinformatics Concentration Learning Outcomes

- Given the rapid development in both biological and clinical data sciences, demand is growing for highly skilled bioinformatics professionals. The rapidly evolving health care industry is in high demand for clinical bioinformatic practitioners. To meet this demand, we created the master program in Clinical Bioinformatics.
- This program is practical, clinically focused and aims at providing the necessary skills to produce high quality bioinformatic workflows to analyze and interpret clinical genomic data. Graduates of this program will have the tools, skills, and resources to develop and improve methods of acquiring, storing, organizing, and assessing clinical and biological data with the aim of supporting and improving patient care and outcomes.
- This program is suitable for a range of students and healthcare professionals including medical students, residents, clinicians, and graduate students in biochemistry, biology, pharmacology, health information, mathematics, statistics, and computer science.
- STUDENT LEARNING OUTCOMES Graduating students WILL BE ABLE TO: 1) Apply clinical bioinformatics theories, methods and tools related to personal health, health care, public health, and biomedical research (for example): a) Work with and evaluate electronic health records, b) Work with and evaluate national health databases, c) Work with and evaluate omics repositories, d) Integrate clinical and omics data.\\n\\n\\n\\n
- 2) Discuss the processes of genome evolution, including (for example): a) Mechanisms of mutation, b) Consequences and exploitation of SNPs, c) Fixation of mutations, d) Genetic drift, e) Phylogenetics, f) Major theories for the origin of novel genes, g) Nature and basis of codon bias.
- 3) Describe and use analytic tools associated with systems/ bioinformatic approaches, including (for example): a) Transcriptomics – microarray analysis vs. deep sequencing, b) Proteomic mass spectroscopic methods (identification and abundance), c) Determining statistical significance in large bioinformatic datasets, d) Determination and structure of interaction networks, e) Functional network maps.
- 4) Understand appropriate statistical analysis of sequence information, including (for example): a) Probabilistic methods, b) Deterministic methods, c) Machine learning methods, including Support Vector Machines (SVMs), d) Cluster analysis.
- 5) Demonstrate competent use of existing bioinformatic and statistical software, including (for example): a) R statistical tools, b) Alignments and their interpretation, c) Phylogenetic analyses, \\nd) Programs to predict genes and transcription factor binding sites, e) Programs to display, predict and analyze 3D biomolecule structures.
- 6) Apply Intelligent Data Analysis Techniques including (for example): a) Dimension reduction techniques, b) Heuristic search techniques, c) Intelligent interfacing techniques.
- 7) Describe application of bioinformatic methods to clinical problems, by demonstrating understanding of: a) Biomarker discovery and validation, b) Major diseases such as cancer, diabetes, and autoimmunity.
- 8) Communicate competently both in writing and orally a) With fellow team members in research projects, b) With the broader scientific public.
- 9) Demonstrate familiarity with and adherence to research ethics.