

Bioinformatics and Medical Informatics

IN THE COLLEGE OF SCIENCES

OFFICE: Physical Sciences 123

TELEPHONE: 619-594-1672

E-MAIL: redwards@sdsu.edu

Associated Faculty

Robert A. Edwards, Ph.D., Professor of Biology, Interim Director of Bioinformatics and Medical Informatics
Andrew J. Bohonak, Ph.D., Professor of Biology, Assistant Dean for Student Services Policy and Curriculum
Nader Amir, Ph.D., Professor of Psychology
Elizabeth A. Dinsdale, Ph.D., Professor of Biology
Willa L. Fields, D.N.Sc., Professor of Nursing
Scott T. Kelley, Ph.D., Professor of Biology
Susan M. Kiene, Ph.D., Professor of Public Health
Sunil Kumar, Ph.D., Professor of Electrical and Computer Engineering
Richard A. Levine, Ph.D., Professor of Statistics
David A. Lipson, Ph.D., Professor of Biology
Hala N. Madanat, Ph.D., Professor and Director of School of Public Health
Georg E. Matt, Ph.D., Professor and Chair of Psychology
Kathleen L. McGuire, Ph.D., Professor of Biology
Robert P. Metzger, Ph.D., Professor of Chemistry, Emeritus
Chunting C. Mi, Ph.D., Professor and Chair of Electrical and Computer Engineering
Ralph-Axel Müller, Ph.D., Professor of Psychology
Claire Murphy, Ph.D., Professor of Psychology
Thomas E. Novotny, M.D., Professor of Public Health, Emeritus
Yusuf Ozturk, Ph.D., Professor of Electrical and Computer Engineering
Forest L. Rohwer, Ph.D., Professor of Biology
Anca M. Segall, Ph.D., Professor of Biology
Usha Sinha, Ph.D., Professor of Physics
Gregory A. Talavera, M.D., Professor of Public Health
Mahmoud Tarokh, Ph.D., Professor of Computer Science
Faramarz Valafar, Ph.D., Professor of Computer Science
Elizabeth R. Waters, Ph.D., Professor of Biology
Tao Xie, Ph.D., Professor of Computer Science
Robert W. Zeller, Ph.D., Professor of Biology
Ashkan Ashrafi, Ph.D., Associate Professor of Electrical and Computer Engineering
Jong-Deuk Baek, Ph.D., Associate Professor of Public Health
Barbara Ann Bailey, Ph.D., Associate Professor of Statistics
B. Mikael Bergdahl, Ph.D., Associate Professor of Chemistry and Biochemistry
Marina Kalyuzhnaya, Ph.D., Associate Professor of Biology
Chii-Dean Lin, Ph.D., Associate Professor of Statistics
John J. Love, Ph.D., Associate Professor of Chemistry and Biochemistry
Ksenija Marinkovic, Ph.D., Associate Professor of Psychology
Mahawseta Sarkar, Ph.D., Associate Professor of Electrical and Computer Engineering
Manal A. Swairjo, Ph.D., Associate Professor of Chemistry and Biochemistry
Wei Wang, Ph.D., Associate Professor of Computer Science
Richard M. Zayas, Ph.D., Associate Professor of Biology
Erica Forsberg, Ph.D., Assistant Professor of Chemistry and Biochemistry
Xiaobai Liu, Ph.D., Assistant Professor of Computer Science
Antoni Luque Santolaria, Ph.D., Assistant Professor of Mathematics
Dwayne R. Roach, Ph.D., Assistant Professor of Biology
Melody Schiaffino, Ph.D., Assistant Professor of Public Health
Jeet Sukumaran, Ph.D., Assistant Professor of Biology
Matthew E. Verbyla, Ph.D., Assistant Professor of Civil, Construction, and Environmental Engineering
Jillian L. Wiggins, Ph.D., Assistant Professor of Psychology

Adjunct Faculty

University of California, San Diego:

Antonino Catanzaro, M.D., Professor of Pulmonary Health
Lucila Ohno-Machado, M.D., Ph.D., Professor of Medicine
Timothy Rodwell, M.D., Ph.D., M.P.H., Associate Professor of Pulmonary Health
Hyeon-Eui Kim, Ph.D, M.P.H., R.N., Assistant Professor of Biomedical Informatics
Siamak Yousefi, Ph.D., Assistant Project Scientist, Shiley Eye Institute

University of California, Los Angeles:

Neema Jamshidi, M.D., Ph.D., Diagnostic Radiology

Public Health Agency of Sweden:

Sven Hoffner, Ph.D., Karolinska Institute

La Jolla Institute for Allergy and Immunology:

Bjoern Peters, Ph.D., Center for Infectious Disease
Anjano Rao, Ph.D., Signaling and Gene Expression Research

VA Hospital:

Alan Calvitti, Ph.D., System Biology

General Information

Bioinformatics and Medical Informatics (BIOMI) are multidisciplinary fields at the intersection of computing and informatics, mathematics and statistics, biology, chemistry, and engineering.

The explosion in genomic information and in the elucidation of pathways of various types has created an unprecedented, but largely unmet, need for professionals with a working knowledge of the biological sciences and computing/statistical methods. The shortage, which is especially severe in the biotechnology and pharmaceutical industries, has been documented by various studies and discussed in the press. We can also observe a comparable demand in hospital and other clinical settings as the impact of new technologies spreads into clinical research and medical practice.

Research and development (R&D) in BIOMI can be categorized into one of three branches. The first branch is the algorithm development branch in which R&D specialists use mathematical and engineering techniques to develop new, more efficient, and/or more accurate methods to mine biological or clinical data. The second branch falls within the software engineering paradigm and primarily focuses on R&D in human-computer interface. The third branch seeks to find answers to specific biological or medical questions including drug development or working to uncover the underlying mechanisms involved in specific biological systems or specific diseases. In the first year of the program, students in consultation with their graduate adviser will take basic courses within two of the following four disciplines: biology, chemistry, computer science, and mathematics/statistics.

For specialization in the algorithm development branch, students can choose courses and projects in areas such as statistics, data mining, pattern recognition, artificial intelligence, search strategies, network architecture, digital image processing and advance imaging, modeling, decisions systems design, and analytical studies in various biological and clinical specializations. For specialization in the human-computer interface branch, students can choose courses and projects in areas such as principals of software design, human interface design, network architecture, usability studies, database design and management, computer graphics and animation, CAD, and programming languages. For the third specialization students take a combination of courses in the areas listed above plus some specialized courses such as computer aided drug design.

The change toward quantitative analysis in life and clinical sciences has been so rapid that universities have been caught unprepared: few offer suitable courses, and virtually none offer a well

integrated curriculum that meets the needs that are sure to grow and evolve as life sciences become increasingly conceptual and quantitative.

San Diego State University's BIOMI graduate program offers two related but distinct tracks. The first is a professional science master concentration preparing students for immediate productivity in industrial or clinical settings. The second is a traditional master of science preparing students for academic setting or continuation in a Ph.D. program.

Admission to Graduate Study

In addition to the general requirements for admission to the university with classified graduate standing, as described in Part Two of the *Graduate Bulletin*, a student must satisfy the following requirements before being considered for recommendation to enter the masters program.

1. Meet the requirements deemed equivalent to a baccalaureate degree in biology, chemistry, computer science, mathematics, statistics, or a field in engineering.
2. Be considered as capable of graduate work in bioinformatics or medical informatics by at least two references who have submitted letters to the BIOMI program director.

Students applying for admission should electronically submit the university application available at <http://www.calstate.edu/apply> along with the \$55 application fee.

Students who do not meet all of the above requirements for admission with classified graduate standing may be admitted with conditionally classified graduate standing upon the recommendation of the research program. Students so admitted will be advised as to the nature of their deficiency and the time to be allowed to achieve full classified graduate standing. Conditions may include satisfactory passing of certain undergraduate courses. These courses will be in addition to the minimum of 33-38 units required for the program.

Graduate Admissions

All applicants must submit admissions materials separately to SDSU Graduate Admissions and to the Bioinformatics and Medical Informatics program.

The following materials should be submitted as a complete package directly to:

Graduate Admissions

Enrollment Services
San Diego State University
San Diego, CA 92182-7416

1. Official transcripts (in sealed envelopes) from all postsecondary institutions attended;
 - Students who attended SDSU need only submit transcripts for work completed since last attendance.
 - Students with international coursework must submit both the official transcript and proof of degree. If documents are in a language other than English, they must be accompanied by a certified English translation.
2. GRE scores (<http://www.ets.org> SDSU institution code 4682);
3. English language score, if medium of instruction was in a language other than English (<http://www.ets.org> SDSU institution code 4682).

Master of Science Degree in Bioinformatics and Medical Informatics

The following materials should be mailed or delivered to:

Bioinformatics and Medical Informatics

(BIOMI) Graduate Program
(Attention: Graduate Adviser)
San Diego State University
5500 Campanile Drive
San Diego, CA 92182-7720

1. Two letters of recommendation (in sealed and signed envelopes) from persons in a position to judge academic ability.
2. Personal statement of motivating interest for the program; also briefly describe research interests and educational and professional goals.

Advancement to Candidacy

All students must satisfy the general requirements for advancement to candidacy, as described in Part Four of this bulletin.

Specific Requirements for the Master of Science Degree

(Major Code: 07994) (SIMS Code: 771490)

In addition to meeting the requirements for classified graduate standing and the basic requirements for the master's degree as described in Part Four of this bulletin, the student must complete a program of study totaling 38 units for the concentration in professional science master and 33 units for the master of science as described below. At least half of the units required must be in 600- and 700-numbered courses. Courses required to remove undergraduate deficiencies are in addition to the minimum number of units required for the degree. **No more than a total of six units in courses numbered 797 and 798 will be accepted toward the degree.**

1. Complete 12 units of required core courses.

BIOMI 568/BIOL 568	Bioinformatics.....	3
BIOMI 600/CS 600	Methods in Bioinformatics, Medical Informatics, and Cheminformatics.....	3
BIOL 510	Molecular Evolution	3
CHEM 560	General Biochemistry.....	3
2. Complementary: Nine units in a field complementary to the student's background with approval of the graduate coordinator selected from the following courses.

BIOMI 609/CS 609	Computational Genomics and Bioinformatics.....	3
BIOL 562	Ecological Metagenomics	3
BIOL 740	Phylogenetic Systematics	3
CHEM 567	Biochemistry Laboratory	3
CS 514	Database Theory and Implementation.....	3
CS 520	Advanced Programming Languages.....	3
CS 532	Software Engineering	3
CS 560	Algorithms and Their Analysis.....	3
CS 605/COMP 605	Scientific Computing	3
CS 615	Spatial Database	3
P H 602	Biostatistics	3
P H 700A	Seminar in Public Health: Epidemiology.....	1-3
STAT 551A	Probability and Mathematical Statistics.....	3
STAT 551B	Probability and Mathematical Statistics.....	3
STAT 680A-680B	Advanced Biostatistical Methods.....	3-3
3. Electives: Six units of approved 500-, 600-, or 700-level electives in disciplines related to the student's specialization with approval of the graduate coordinator.
4. Six units of research including Thesis:

BIOMI 797	Research.....	(3) Cr/NC/RP
BIOMI 799A	Thesis or Project.....	(3) Cr/NC/RP

Professional Science Master Concentration

(Major Code: 07994) (SIMS Code: 771489)

1. Complete 12 units of required core courses.

BIOMI 568/BIOL 568	Bioinformatics.....	3
BIOMI 600/CS 600	Methods in Bioinformatics, Medical Informatics, and Cheminformatics.....	3
BIOL 510	Molecular Evolution	3
CHEM 560	General Biochemistry.....	3

Bioinformatics and Medical Informatics

2. Complementary: Twelve units in a field complementary to the student's background with approval of the graduate coordinator selected from the following courses.

CHEM 567	Biochemistry Laboratory	3
CS 514	Database Theory and Implementation.....	3
CS 520	Advanced Programming Languages.....	3
CS 605 or COMP 605	Scientific Computing	3
STAT 551A	Probability and Mathematical Statistics.....	3
STAT 551B	Probability and Mathematical Statistics.....	3
3. Electives: Nine units of approved 500-, 600-, or 700-level electives in disciplines related to the student's specialization with approval of the graduate coordinator.
4. Five units of research including Thesis:

BIOMI 797	Research.....	2 (Cr/NC/RP)
-----------	---------------	--------------

OR

BIOMI 798	Special Study.....	2 (Cr/NC/RP)
BIOMI 799A	Thesis or Project.....	3 (Cr/NC/RP)

Courses Acceptable for Master's Degree Program in Bioinformatics and Medical Informatics (BIOMI)

Refer to Courses and Curricula and Regulations of the Division of Graduate Affairs sections of this bulletin for explanation of the course numbering system, unit or credit hour, prerequisites, and related information.

UPPER DIVISION COURSES

BIOMI 568. Bioinformatics (3) (Same course as Biology 568)

Two lectures and three hours of laboratory.
Prerequisite: Biology 366.

Bioinformatics analysis methods and programming skills. Practical bioinformatic software for sequence analysis, bioinformatic algorithms and programming fundamentals.

BIOMI 596. Special Topics in Bioinformatics and Medical Informatics (1-4)

Prerequisite: Consent of instructor.

Advanced selected topics in bioinformatics and medical informatics. May be repeated with new content. See *Class Schedule* for specific content. Limit of nine units of any combination of 296, 496, 596 courses applicable to a bachelor's degree. Credit for 596 applicable to a master's degree with approval of the graduate adviser.

GRADUATE COURSES

BIOMI 600. Methods in Bioinformatics, Medical Informatics, and Cheminformatics (3) (Same course as Computer Science 600)

Prerequisites: Three units of calculus and graduate standing. Computer, mathematical, and engineering techniques for bioinformatics, cheminformatics, and medical informatics. Techniques used in microarray data analysis, gene and protein sequence alignment, and classification techniques in medical decision making.

BIOMI 609. Computational Genomics and Bioinformatics (3) (Same course as Computer Science 609)

Prerequisite: Computer Science 503 or 514.

Biological and genomic data. Application of computational algorithms to biological questions. Post-genomic techniques in annotation and comparison of microbial and eukaryotic genome sequences.

BIOMI 696. Advanced Topics in Bioinformatics and Medical Informatics (1-3)

Prerequisite: Graduate standing in bioinformatics and medical informatics or consent of instructor.

Recent technological developments and scientific breakthroughs that have a changing effect on the field of biomedical informatics. May be repeated with new content. See *Class Schedule* for specific content. Credit for 696 applicable to a master's degree with approval of the graduate adviser.

BIOMI 796. Selected Topics in Bioinformatics and Medical Informatics (1-3)

Prerequisite: Graduate standing in bioinformatics and medical informatics or consent of instructor.

Intensive study in specific areas of biological or medical informatics. In-depth investigation of specific challenges in the field as well as introduction to current and emerging technologies. May be repeated with new content. See *Class Schedule* for specific content. Credit for 796 applicable to a master's degree with approval of the graduate adviser.

BIOMI 797. Research (1-3) Cr/NC/RP

Prerequisite: Consent of instructor.

Research in one of the fields of bioinformatics and medical informatics. Maximum credit six units applicable to a master's degree.

BIOMI 798. Special Study (1-3) Cr/NC/RP

Prerequisite: Consent of staff; to be arranged with graduate coordinator.

Individual study. Maximum credit six units applicable to a master's degree.

BIOMI 799A. Thesis or Project (3) Cr/NC/RP

Prerequisites: An officially appointed thesis committee and advancement to candidacy.

Preparation of a project or thesis for the master's degree.

BIOMI 799B. Thesis Extension (0) Cr/NC

Prerequisite: Prior registration in Thesis 799A with an assigned grade symbol of RP.

Registration required in any semester or term following assignment of RP in Course 799A in which the student expects to use the facilities and resources of the university; also student must be registered in the course when the completed thesis is granted final approval.