BIOMEDICAL DATA SCIENCE, PH.D.

The current explosion of biomedical data provides an awesome opportunity to improve understanding of the mechanisms of disease and ultimately to improve human health care. However, fully harnessing the power of high-dimensional, heterogeneous data requires a new blend of skills including programming, data management, data analysis, and machine learning.

Blending the best of statistics and computer sciences, biostatistics and biomedical informatics, this program provides students the training they need to make sense of large-scale biomedical data, and to be scientific leaders in the team science that invariably accompanies such data. Unique features of the program include cross-training in computer science and biostatistics, and research rotations mentored by a program faculty member jointly with a scientific collaborator.

ADMISSIONS

GRADUATE SCHOOL ADMISSIONS

Graduate admissions is a two-step process between academic degree programs and the Graduate School. Applicants must meet requirements of both the program(s) and the Graduate School. Once you have researched the graduate program(s) you are interested in, apply online (https://grad.wisc.edu/admissions).

Applying to the Program:
- A formal online application (https://grad.wisc.edu/apply) with required fee through the UW–Madison Graduate School
- Three letters of recommendation
- Transcripts from each higher-education institution attended
- A statement of purpose
- GRE or MCAT scores
- Applicants whose native language is not English, or whose undergraduate instruction was not in English, must provide an English proficiency test score (TOEFL, MELAB, or IELTS)
- Evidence of quantitative preparation, including at least two semesters of college calculus (similar to MATH 221–MATH 222) and either a course in linear algebra (similar to MATH 340) or courses in programming and data structures

Application Deadline: December 31

For additional information about admission to the program, see PhD Program in Biomedical Data Science (https://www.biostat.wisc.edu/PHD-Biomedical-Data-Science) on the department website.

FUNDING

GRADUATE SCHOOL RESOURCES

Resources to help you afford graduate study might include assistantships, fellowships, traineeships, and financial aid. Further funding information (https://grad.wisc.edu/funding) is available from the Graduate School. Be sure to check with your program for individual policies and processes related to funding.

PROGRAM RESOURCES

The program is designed such that almost all students who are accepted to the program will receive guaranteed funding for five years. This funding may take a number of forms including, but not limited to training grants, teaching assistantships, and research assistantships. For more information about funding opportunities, see Graduate Assistantships (https://grad.wisc.edu/studentfunding/currentstudents).

REQUIREMENTS

MINIMUM GRADUATE SCHOOL REQUIREMENTS

Review the Graduate School minimum academic progress and degree requirements (http://guide.wisc.edu/graduate/#policiesandrequirementstext), in addition to the program requirements listed below.

MAJOR REQUIREMENTS

MODE OF INSTRUCTION

<table>
<thead>
<tr>
<th>Mode of Instruction</th>
<th>Face to Face</th>
<th>Evening/Weekend</th>
<th>Online</th>
<th>Hybrid</th>
<th>Accelerated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

Mode of Instruction Definitions

Evening/Weekend: These programs are offered in an evening and/or weekend format to accommodate working schedules. Enjoy the advantages of on-campus courses.
and personal connections, while keeping your day job. For more information about the meeting schedule of a specific program, contact the program.

**Online:** These programs are offered primarily online. Many available online programs can be completed almost entirely online with all online programs offering at least 50 percent or more of the program work online. Some online programs have an on-campus component that is often designed to accommodate working schedules. Take advantage of the convenience of online learning while participating in a rich, interactive learning environment. For more information about the online nature of a specific program, contact the program.

**Hybrid:** These programs have innovative curricula that combine on-campus and online formats. Most hybrid programs are completed on-campus with a partial or completely online semester. For more information about the hybrid schedule of a specific program, contact the program.

**Accelerated:** These on-campus programs are offered in an accelerated format that allows you to complete your program in a condensed time frame. Enjoy the advantages of on-campus courses with minimal disruption to your career. For more information about the accelerated nature of a specific program, contact the program.

## CURRICULAR REQUIREMENTS

<table>
<thead>
<tr>
<th>Requirements Detail</th>
<th>Minimum Credit Requirement</th>
<th>Minimum Residence Credit Requirement</th>
<th>Minimum Graduate Coursework Requirement</th>
<th>Overall Graduate GPA Requirement</th>
<th>Other Grade Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Credit Requirement</td>
<td>51 credits</td>
<td></td>
<td></td>
<td>3.00 GPA required</td>
<td>Ph.D. candidates should maintain a 3.5 GPA in all core curriculum courses and may not have any more than two Incompletes on their record at any one time.</td>
</tr>
<tr>
<td>Minimum Residence Credit Requirement</td>
<td>32 credits</td>
<td></td>
<td></td>
<td></td>
<td>Students must complete an Oral Preliminary Exam, ideally taken in the students’ third year.</td>
</tr>
<tr>
<td>Minimum Graduate Coursework Requirement</td>
<td>26 out of 51 total credits</td>
<td>Half of degree coursework; courses with the Graduate Level Coursework attribute are identified and searchable in the university’s Course Guide.</td>
<td>3.00 GPA required</td>
<td></td>
<td>No language requirements.</td>
</tr>
<tr>
<td>Overall Graduate GPA Requirement</td>
<td>3.00 GPA required</td>
<td></td>
<td></td>
<td></td>
<td>All doctoral students are required to complete a minor.</td>
</tr>
</tbody>
</table>

### REQUIRED COURSES

**CORE TOPICS**

Three year-long course sequences (18 credits) will be selected from a set of core topics.

1. A Biostatistics Theory and Methods sequence (topics 1–3)
2. A Computer Science/Informatics sequence (topics 4–7)
3. A sequence from any of the listed topics from Biostatistics Theory and Methods, Computer Science/Informatics, and the Specializations (topics 1–12)

### SEQUENCES IN BIOSTATISTICS THEORY AND METHODS (TOPICS 1–3)

#### Topic 1: Biostatistics Theory and Methods—Mathematical Statistics AND Introduction to Statistical Inference

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>STAT 609 &amp; STAT 610</td>
<td>Mathematical Statistics I and Introduction to Statistical Inference</td>
<td>7</td>
</tr>
</tbody>
</table>

#### Topic 2: Biostatistical Methods—Statistical Methods Series OR Regression Theory and Application Series

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>STAT 601 &amp; STAT 602</td>
<td>Statistical Methods I and Statistical Methods II</td>
<td>8</td>
</tr>
<tr>
<td>STAT 849 &amp; STAT 850</td>
<td>Theory and Application of Regression and Analysis of Variance I and Theory and Application of Regression and Analysis of Variance II</td>
<td>6</td>
</tr>
</tbody>
</table>

#### Topic 3: Applied Biostatistics—Data Science AND Data Visualization

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>STAT 628 &amp; COMP SCI 765</td>
<td>Data Science Practicum and Data Visualization</td>
<td>6</td>
</tr>
</tbody>
</table>

### SEQUENCES IN COMPUTER SCIENCE / INFORMATICS (TOPICS 4–7)

#### Topic 4: Machine Learning / AI—Intro to Artificial Intelligence AND Machine Learning

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMP SCI 540 &amp; COMP SCI 760</td>
<td>Introduction to Artificial Intelligence and Machine Learning</td>
<td>6</td>
</tr>
</tbody>
</table>

#### Topic 5: Database Systems—Database Management AND Database Management Topics

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMP SCI 564 &amp; COMP SCI 764</td>
<td>Database Management Systems: Design and Implementation and Topics in Database Management Systems</td>
<td>7</td>
</tr>
</tbody>
</table>

#### Topic 6: Optimization—Linear Program Methods AND Nonlinear Optimization

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMP SCI/I SY E/MATH/STAT 525 &amp; COMP SCI/I SY E/MATH/STAT 726</td>
<td>Linear Optimization and Nonlinear Optimization I</td>
<td>6</td>
</tr>
</tbody>
</table>

#### Topic 7: Algorithms—Introduction to Algorithms AND Advanced Algorithms

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMP SCI 577 &amp; COMP SCI 787</td>
<td>Introduction to Algorithms and Advanced Algorithms</td>
<td>7</td>
</tr>
</tbody>
</table>
SEQUENCES IN ADDITIONAL SPECIALIZATIONS (TOPICS 8-12)

**Topic 8**: Clinical Informatics—Health Systems Engineering AND Health Information Systems

- Code: I SY E 417
- Title: Health Systems Engineering and Health Information Systems
- Credits: 6

**Topic 9**: Clinical Biostatistics—Clinical Trials Statistical Methods AND Epidemiological Statistical Methods

- Code: B M I/STAT 641
- Title: Statistical Methods for Clinical Trials
- Credits: 6
- Code: & B M I/STAT 642
- Title: and Statistical Methods for Epidemiology

**Topic 10**: Statistical Computing—Statistical Computing AND Professional Skills for Data Science

- Code: STAT 771
- Title: Statistical Computing and Professional Skills in Data Science
- Credits: 6
- Code: & STAT 627

**Topic 11**: Bioinformatics / Statistical Genomics—Introduction to Bioinformatics AND Advanced Bioinformatics OR Statistical Methods for Molecular Biology

- Code: B M I/COMP SCI 576
- Title: Introduction to Bioinformatics
- Credits: 6
- Code: & COMP SCI/ or STAT 776
- Title: and Advanced Bioinformatics
- Code: B M I 877
- Title: Statistical Methods for Molecular Biology

**Topic 12**: Biomedical Image Analysis (2 of 3)—Computer Vision OR Computer Methods for Medical Image Analysis OR Statistical Methods for Medical Image Analysis

- Code: COMP SCI 766
- Title: Computer Vision
- Credits: 3
- Code: B M I/COMP SCI 767
- Title: Computational Methods for Medical Image Analysis
- Credits: 3
- Code: B M I/STAT 768
- Title: Statistical Methods for Medical Image Analysis
- Credits: 3

ADDITIONAL REQUIREMENTS

In consultation with their faculty advisor, students will select 6 credits of biology courses, 6 credits of elective courses, and a research ethics course (1 credit). Students will also complete:

**A second-year literature seminar (4 credits)**

- Code: B M I 881
- Title: Biomedical Data Science Scholarly Literature 1
- Credits: 2
- Starting Fall 2019

- Code: B M I 882
- Title: Biomedical Data Science Scholarly Literature 2
- Credits: 2
- Starting Fall 2019

**A third-year professional skills seminar (2 credits)**

- Code: B M I 883
- Title: Biomedical Data Science Professional Skills 1
- Credits: 1
- Starting Fall 2019

Three semester-long research rotations concerning a substantive problem in biomedical data science, advised by a program faculty member in collaboration with a UW faculty member from the biological, biomedical, or population health sciences.

**Code** | **Title** | **Credits**
--- | --- | ---
B M I 889 | Pre-dissertation Research | 3

**POLICIES**

**GRADUATE SCHOOL POLICIES**

The Graduate School's Academic Policies and Procedures (https://grad.wisc.edu/acadpolicy) provide essential information regarding general university policies. Program authority to set degree policies beyond the minimum required by the Graduate School lies with the degree program faculty. Policies set by the academic degree program can be found below.

**MAJOR-SPECIFIC POLICIES**

**GRADUATE PROGRAM HANDBOOK**

The Graduate Program Handbook (https://www.biostat.wisc.edu/sites/default/files/Handbook2017.pdf) is the repository for all of the program's policies and requirements.

**PRIOR COURSEWORK**

**Graduate Work from Other Institutions**

With program approval, students are allowed to count no more than 9 credits of graduate course work from other institutions toward the graduate degree credit and graduate course work (50%) requirements. Course work earned ten years or more prior to admission to a doctoral degree is not allowed to satisfy requirements.

**UW–Madison Undergraduate**

For well-prepared advanced students, a student’s program may decide to accept up to 7 credits numbered 300 or above of required or elective courses from the undergraduate work completed at UW–Madison toward fulfillment of minimum degree and minor credit requirements. However, this work would not be allowed to count toward the 50% graduate course work minimum unless taken at the 700 level or above. This work will not appear on the graduate career portion of UW–Madison transcript nor count toward the graduate career GPA. The Graduate School’s minimum graduate residence credit requirement can be satisfied only with courses taken as a graduate student at UW–Madison.

**UW–Madison University Special**

After admission to a graduate program, the student’s program may decide to accept up to fifteen University Special student credits as fulfillment of the minimum graduate residence, graduate degree, or minor credit requirements on occasion as an exception (on a case-by-case basis). In all these cases, the student would have to pay the difference in tuition for the terms in question. UW–Madison course work taken as a University Special student would not be allowed to count toward the 50% graduate course work minimum unless taken at the 700 level or above. This work will not appear on the
graduate career portion of UW–Madison transcript nor count toward the graduate career GPA.

PROBATION

The status of a student can be one of three options:

1. Good standing (progressing according to standards; any funding guarantee remains in place).
2. Probation (not progressing according to standards but permitted to enroll; loss of funding guarantee; specific plan with dates and deadlines in place in regard to removal of probationary status).
3. Unsatisfactory progress (not progressing according to standards; not permitted to enroll, dismissal, leave of absence or change of advisor or program).

ADVISOR / COMMITTEE

All students are required to conduct a yearly progress report meeting with their advisor, scheduled by December 17 and completed by April 30. Failure to do so will result in a hold being placed on the student’s registration.

CREDITS PER TERM ALLOWED

15 credits

TIME CONSTRAINTS

If students have been absent for five or more years, they must file a new Graduate School application for admission and submit it with a new application fee.

A candidate for a doctoral degree who fails to take the final oral examination and deposit the dissertation within five years after passing the preliminary examination may by require to take another preliminary examination and to be admitted to candidacy a second time.

OTHER

Funding guarantees are not provided for students in this program. Students are encouraged to explore funding options available across campus.

PROFESSIONAL DEVELOPMENT

GRADUATE SCHOOL RESOURCES

Take advantage of the Graduate School’s professional development resources ([https://grad.wisc.edu/pd](https://grad.wisc.edu/pd)) to build skills, thrive academically, and launch your career.

LEARNING OUTCOMES

1. Articulate the biological context of a research question and the scientific relevance of analysis results.
2. Communicate with scientific and quantitative (computational and statistical) colleagues about data analysis goals, methods, and results.
3. Extract the statistical or computational problems from a scientific problem. Develop, characterize, and implement suitable analysis methods to answer questions from biomedical data. Evaluate the validity of analysis methods.
4. Analyze data; extract knowledge and guide decisions based on biomedical data. Organize data and software so that quantitative analyses are meaningful and reproducible.
5. Critically evaluate quantitative approaches in the scientific literature.
6. Evaluate and develop study designs and recognize limitations and potential biases in research data sets.
7. Identify the ethical and regulatory issues surrounding a research project.
8. As part of a biological, biomedical or population health investigative team, serve as the leader in the area of rigorous computational and statistical investigation.

PEOPLE

Faculty: Broman, Buchanan, Burnside, Chappell, Chen, Chung, Craven, Dewey, Doan, Dyer, Elwert, Gangnon, Gianola, Gitter, Keles, Kendziorski, Kim, Lu, Mao, Mendonça, Mumford, Newton, Ong, Page, Palta, Patel, Peissig, Rathouz (chair), Rosa, Rosenberg, Roy, Singh, Sorkness, Tang, Wahba, Yandell, Velten, Yu, Zhang, Zhu